Learning through cooperative education work placements in science and technology

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Abstract

Cooperative education (co-op) is a strategy of education that includes a requirement for successful completion of both formal classwork and work placements to gain a qualification. The work placements immerse the student in relevant productive work, and are seen as an integral part of the educational programme.

Although there is anecdotal and research data in the literature about the success of co-op programmes, little theorising and research about learning in placements has been published which could help practitioners legitimise their co-op placements as educational, and enhance development of appropriate pedagogy and curricula for co-op programmes. Sociocultural views of learning, that depict learning as a mediated, situated and participatory activity within a socially and culturally determined community of practice, were proposed to address these concerns.

This study addressed the lack of theoretical understanding of co-op by investigating, through a sociocultural view of learning lens, what and how a cohort of co-op students learnt through undertaking work placements in science and technology. An interpretive methodology was adopted to probe the students' experiences within the placements they carried out as part of their BSc(Tech) degree programmes at the University of Waikato.

This study found that student learning in co-op work placements can be viewed as a socially mediated, situated and participatory activity. Most learning was achieved by working alongside a practising professional, engaged in authentic activities, as the students gained legitimate access to a new community of practice and became enculturated into ways of thinking and acting as a member of that community. The students learnt through social interactions, and the use of the language and other tools of the community.

The students learnt about the practice of science and technology through their participation in science and technology workplaces. They came to understand the

nature of the workplace enterprise, and developed specific skills and knowledge that allowed them to feel part of their community.

This study has found that student learning in co-op placements can be seen as complementary to university classroom learning. Students felt they could integrate their learning between the two settings when they could apply discrete skills or knowledge from one to the other. Yet, for some students who could see little integration between their placement learning and that of the university classroom, learning in each setting may still complement the other to provide a valuable education. The students noted different learning and assessment modes between the two environments, indicating that they would benefit from a pedagogical and curriculum design in their co-op programme that would help ease the transition between the two.

From a sociocultural perspective, these co-op students can be seen as learning within two distinct socially and culturally-determined communities of practice, the university and the workplace. How they are able to make connections between these communities, with the help of the co-op placement coordinator, will determine how they make the transition between student to science and technology practitioner.

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Chapter 1 Introduction

1.1 What is cooperative education?

Cooperative education is a strategy of education that involves collaboration between a student, an educational institution and an employer, hence the use of the term cooperative. The World Association of Cooperative Education (WACE) describes how the strategy "enhances classroom learning by integrating academic curriculum and real-world experience" (WACE, 2002, p.4). The New Zealand Association for Cooperative Education (NZACE) further explains that it requires that "relevant and productive work is an integral part of the student's regular academic programme and is an essential component of the final assessment" (NZACE, 1995, p.1). Cooperative education entails students undertaking work placements that immerse them in appropriate *productive* work leading to learning, such that they do not simply act as passive observers within a workplace (Watts, 1983).

The cooperative education movement began in the USA in 1906 and has grown to include programmes in at least 39 countries of the world (WACE, 2001b, 2002). Originally trialled in engineering programmes, it has diversified into "virtually every curriculum, from the technical, scientific, and professional disciplines to the humanities and the social sciences" (WACE, 1994, p.2). More recently there has been a realisation that cooperative education programmes are very similar to many apprenticeship schemes, teacher practicums, nursing internships and field experience programmes. With this in mind the term cooperative education is also known as work-integrated learning, in order to more clearly describe the integration of academic learning with real-world work experience (NZACE, 2001; WACE, 2001a). For the duration of this thesis, however, the term cooperative education will be used as it has remained the prevalent term used in New Zealand throughout the time of this study.

Combining periods of employment within an academic programme has been claimed to allow students to apply their academic knowledge to workplace

problems, learn about potential career options through experience, and make useful contacts; to allow employers to get short-term productive projects completed by placement students, and preview potential employees, which can make recruitment simple and cost-effective; and to provide enhanced student attraction for an educational institution and a gateway for those institutions to collaborate with employers (NZACE, 1995; WACE, 1994). These benefits have contributed to increasing numbers of cooperative education-type programmes in New Zealand (Eames, 1998) and around the world (WACE, 2001b).

1.2 Background to the study

I had been involved as a placement coordinator in a cooperative education (co-op) programme, the Bachelor of Science(Technology) (BSc(Tech)), at the University of Waikato since 1993. I had ideas about, and anecdotal evidence for, what worked in our programme, but I had some questions too, about why and how it worked. The questions I had about cooperative education stemmed from my position as a biology lecturer and co-op professional at the University of Waikato in New Zealand. I had become aware from my involvement in both the university classroom and the workplace that the practice of science was often not the same in these two places, and that learning in each could therefore be different. This led to a curiosity about how a student experienced the transition between the two, particularly in terms of learning experiences.

In my work as a co-op professional I had experienced, like many of my colleagues in other programmes, many of the successes of cooperative education such as securing excellent placements for students; students gaining more certainty about their career direction through completing placements, and more confidence in their ability to work; retention of employers in the programme year after year through successful placements; collaborations between those employers and the university extending beyond the cooperative education arena; and graduates getting career-related jobs, often with their co-op employers (Chapman, 1994). By these criteria it appeared our programme was successful in its operational aims.

What was less clear was how the educative processes in the placements worked. From attending local and international co-op conferences, it appeared that there was a general lack of knowledge and understanding amongst co-op practitioners about student learning on placement. This was echoed by the cooperative education literature, in which there was relatively little published research on the subject, and which contained calls for research to be done into student learning on placement (Ryan, Toohey, & Hughes, 1996; Stull, Crow, & Braunstein, 1997; Van Gyn, Cutt, Loken, & Ricks, 1997; Wilson, 1989). These calls also spoke of the need for cooperative education programmes to be seen as legitimately academic in order to hold their place as academic programmes, particularly at the tertiary level (Branton et al., 1990; Heinemann, 1988).

Amongst the cooperative education fraternity, there seemed to be some good understanding of the "cooperative" aspect but less of the "education." This study sought to address this deficit through investigating student learning in cooperative education programmes, particularly with respect to the work placement component. The following research questions were posed in this inquiry:

1. What and how does a student learn through cooperative education work placements in science and technology?

2. What roles do the work placements in cooperative education programmes play in facilitating the transition from student to practitioner of science and technology?

In addressing the first question, this study sought to provide a better understanding of the learning outcomes and processes of a student on a co-op work placement. This understanding is important from a pedagogical and curriculum point of view, as the knowledge may help to better prepare students for their learning experiences whilst on placement, to enhance those learning experiences during site visits to the students on placement, and to more fairly assess the learning that they achieve on placement. The findings may also be of use in providing a justification for inclusion of work placements in an educational programme.

In consideration of the second question, the study sought to gain a better understanding of how the learning in the classroom (i.e. at university) can be integrated with the learning in the work placement for students. The structure of many co-op programmes has been designed to allow this. For example, most co-op programmes in England are designed so that a period of work (often a full year) is sandwiched between two full years of coursework study (hence the name used for such programmes – sandwich education). Many other programmes, particularly those in North America, alternate semesters of classroom study with work placements. The understanding of how learning is integrated between the workplace and the classroom is important from a curriculum and pedagogical design point of view, but also for preparing the students for work in science and technology. It may also provide a clearer understanding of the role co-op programmes can play in bridging the gap between the world of the student and the world of work.

To explore these questions, this study followed a cohort of 22 students enrolled in the BSc(Tech) degree at the University of Waikato over the course of their degrees. A description of the BSc(Tech) programme follows.

1.3 Cooperative education at the University of Waikato

A cooperative education programme has been offered at the University of Waikato in science and technology since 1974. This BSc(Tech) degree programme places around 170 students per year. Other work-integrated learning programmes operating at the University include teaching, management, clinical psychology and electronic-commerce.

The BSc(Tech) programme is a four-year degree in contrast with the non - co-op three-year BSc degree also offered at the University. A number of science majors are offered in the programme such as physics, chemistry, biology, the earth sciences, material science, computer science, and a variety of multi-disciplinary programmes, such as biochemistry, biotechnology, forestry and environmental science. Essentially the degree consists of a BSc with the addition of two

management papers and a total of twelve months relevant paid work experience. This work experience comprises two work placements, one of three months duration at the end of the second year, and the other of nine months duration at the end of the third year (Coll, 1996) (see Figure 1.1).

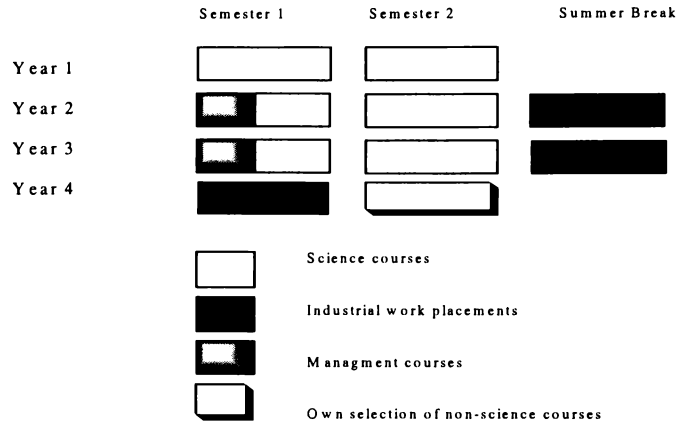

Figure 1.1. Structure of the BSc(Tech) degree (Coll, 1996)

The work placement component is compulsory for the degree and consists of five paper credits out of the 28-paper degree. The goals of the placement programme are to provide students with a genuine employment experience in science and technology by placing them in a productive role relevant to their career interests. Students are expected to be able to learn what it is like to work in science and technology. Students are also expected to be able to integrate their learning of skills and knowledge between the university and the workplace. In this programme students undertake two years of study at the university before carrying out their first placement of three months over the summer vacation at the end of the second year (November to February). They then return to the university for their third year of study, and at the end of that year undertake a second placement that can be either three months or eight months in duration. Some students are finished their degree at this point while others return to the university to complete courses.

Student placements are organized by co-op coordinators who are also faculty members (Coll & Eames, 2000). As noted earlier, I have worked as a co-op coordinator in the programme since 1993. My position is a joint appointment with

some of my time spent in coordinating placements for students in biological sciences, and some spent lecturing in biochemistry and microbiology. This position allows me to experience student learning and my own teaching both in the traditional sphere of the university classroom and in the co-op-styled work placement. The joint appointment also allows for enhanced matching of students with employers for placements, and development of collaborative opportunities between employers and university staff (Coll & Eames, 2000), such as shared research and contract work.

The work placements are in a great variety of workplaces and a difficulty faced in this study was how to account for this variety. In a very general way the workplaces can be described as either public research institutes, private commercial/manufacturing companies or local government organisations, and these categories were used to describe the nature of the placement, and to orientate questions associated with learning in a particular workplace.

Many of the students are placed away from the city in which the University is based, adding complexity to their experience and to my study. In most cases the students are given little choice about their work location as the low population base in New Zealand does not support large numbers of science and technology enterprises in every town and city.

The placement process begins with an interview between the student and their subject-specific coordinator to ascertain the student's career interests. The coordinator then approaches appropriate employers to gauge interest in employing a student, and then facilitates student applications for positions offered. After securing placements for all students, the coordinator visits the students once they are in the workplace to encourage students in their learning, and assist in the assessment of the placement. Assessment of the work placement is by two components: a report written by the student about the work they have done, the organisation they have worked for and what they believe they have achieved in the placement, and which is marked by a member of the appropriate university faculty; and an evaluation of their work performance by their employer. The

courses are awarded a letter grade[1] in the same way as all other university-based courses.

This study sought to explore what and how students learn through work placements and how that learning complements, and integrates with, learning at university in a co-op programme. As the students were situated in the context of New Zealand tertiary education, and in science and technology, backgrounds to these two contexts are now briefly described.

1.4 The New Zealand tertiary education context

In this section I provide a short background to the New Zealand tertiary education environment in which the students found themselves. An understanding of this background is important for the context of influences on, and decisions made by, students about and during their degree programme.

The tertiary education sector in New Zealand at the time of the study was composed in the public sector of seven universities, 25 polytechnics/institutes of technology, four Colleges of Education and three wananga (Maori learning institutions), as well as over 800 private training establishments (PTEs) (Ministry of Education, 1998). Traditionally the universities have catered to degree-level education aspirants with an emphasis on the professions. The other institutions have provided certificate and diploma-level education with an emphasis towards technical trades. These latter institutions have often incorporated elements of work experience in their curricula, emphasising the importance of practice in these learning areas, whereas universities have been less inclined to include work placements in their profession-oriented programmes in New Zealand (Eames, 1998).

In recent years the polytechnic sector has moved increasingly towards degree-level courses in an effort to compete with universities for students, to gain greater access to government funding, and to gain parity with universities in the tertiary

[1] Letter grades are awarded from A+ (>80%) to D (<50%, a fail).

education marketplace. This has moved the polytechnics away from their traditional strength of trades training, and a concomitant decline in the availability of apprenticeships has led to a general concern about school to work transition. An Organisation for Economic Co-operation and Development (OECD) review in the 1990s in other countries noted an increasing linkage between tertiary study and vocational pathways, with more education in vocations and more vocationalisation of education (Skill New Zealand, 2000, p.5). It identified "workplace experience as an important means of matching employers and young people and improving the quality of young people's learning by making it more applied and relevant" (Skill New Zealand, 2000). One strategy that the current New Zealand Government has implemented recently is the Modern Apprenticeship Scheme (MAS), which aims to get more young people back into apprenticeships, and employs coordinators to facilitate the workplace experiences, much in the same way that co-op coordinators do (Strathdee, 2000). This is indicative of a general interest by the Government in the value of integrating work with learning.

Competition for students and resources now exists across all segments of the tertiary education sector. In 1994 the Todd Report set out conditions for funding of tertiary education that encouraged this competitiveness (Todd, 1994). This report also specified that the appropriate level of funding for institutions should be 75% government / 25% other sources. These other sources were to include outside contracts, grants and student fees. As a consequence competition for students has become fierce with much money spent on attracting students. Government funding has continued to reduce and now is at a level where only 62% comes directly from the Government's education budget at the University of Waikato (University of Waikato, 2002). To cover costs, student fees have risen dramatically over the past five years (University of Waikato, 1998-2002). Along with this increase the government introduced a student loan scheme in the mid-1990s, which has allowed students to borrow substantial sums of money to pay for their fees and living costs. This has led to students completing their qualifications owing an average of NZ$13,000 and some students owing NZ$150,000 or more (Association of University Staff, 2003).

Although the loans scheme has been credited with allowing increased participation in tertiary education, this has been mainly at the low-cost certificate and diploma level, and the high cost of fees and loan debt has driven down participation at university-level in recent years. From my discussions with prospective tertiary students and their parents, these factors have also generally led to an increasing drift towards degree courses where jobs and good salaries are better prospects, such as law and business, and away from science and technology.

These changes have increased pressure on universities and their students. They have led to increasing demands for quality, relevant education from students, and a need for justification for teaching programmes from university administration. Co-op placements have often been viewed as an add-on and pressure has been applied to justify to the administration the cost of running a programme. The need to understand the role that co-op placements play in the education of the students has been accentuated. At the same time though co-op programmes have become increasingly popular with students who see the placements as a financial means to offset study costs and a way to get a foot-in-the-door for their first job. This has enhanced student recruitment in many cases, including at the University of Waikato, with many BSc(Tech) students commenting to me that the main reason for taking the degree over other science programmes was the work placement component.

It can therefore be argued that co-op programmes are beginning to play an important role in New Zealand tertiary education. There is evidence of governmental support (Labour Party, 2003) for the strategy in recent education developments in this country, and both students and institutions are increasingly recognizing the possible benefits of co-op programmes. In order that these programmes deliver on their potentials there is a need for research into the pedagogical and curriculum issues that confront the integration of the classroom and workplace learning environments in these programmes.

This study has its focus on the disciplines of science and technology and the final background section to this chapter provides some New Zealand context to these areas.

1.5 The New Zealand science and technology context

New Zealand has historically built its wealth and economic structure on primary products such as dairy produce, meat and wool, and more recently timber. The science and technology research carried out in the country reflects this bias along with a small amount of work done in contributing industries and local government organisations (Ministry for Research in Science and Technology, 2003).

In 1992 the New Zealand Government restructured public science and technology into 10 (now nine) Crown Research Institutes (CRIs). These institutes operate as commercial companies with shareholding and profits residing with the Government (Pockley, 1998). They are mainly funded by the Government through a grant system of competitive bidding, although increasingly they have been expected to rely on commercial sources of income. This has led to a regular restructuring of the CRIs, job insecurity and poor salaries, particularly for technical staff beginning their science careers. The level of government funding on public science and technology is low in comparison with other OECD countries with expenditure running between 0.5 – 0.6% of Gross Domestic Product (GDP) where the OECD average is about 0.7% (Petersen, 1998; Pockley, 1998; West, 2000).

Since their inception the CRIs have adopted a more profit-orientated approach, which has placed demands on scientists and technologists to undertake roles other than science and technology research. It would be fair to say that a career in public science and technology research in New Zealand is not particularly attractive and many graduates and experienced researchers have left the country for better positions (Pockley, 1998; West, 2000; Wilkins, 2001). One factor that would help to rectify this situation would be a period of greater certainty of funding leading to more job security for the science and technology practitioners

in the public domain, a call that has been made by commentators for some time now (Upton, 1995).

As noted earlier New Zealand does not have a large manufacturing base and increasingly the industrial companies present in New Zealand are foreign-owned. In practice these companies do offer a ready job market at the technical level but offer few positions in science leadership or management. In addition many of these companies have opted to conduct all their research and development (R&D) in their parent country, leaving few, and small, R&D laboratories for science and technology graduates in which to begin a career. Private sector investment in R&D has been low historically and in the mid-1990s was about 0.26% of GDP (Pockley, 1998) and in 1999 it was reported to be the second-lowest in the OECD (West, 2000). These factors place increased importance on the value of co-op programmes in science and technology in building partnerships with the private sector and providing a defined career entry path for graduates.

The other main area of science, but not so much technology, employment opportunities is the local government organisations, the councils. These regulatory bodies have a mandate to monitor and care for the urban areas and the environment in their regions according to the New Zealand Resource Management Act (1991). These organisations employ a number of science graduates to carry out this work but in my experience the demand for these jobs has raised the qualification level required and they are hard to secure.

A further consideration for encouraging tertiary students into a career in science and technology has been conflicting signals within the country regarding the status of a career in science and technology. On the one hand Government rhetoric has supported the need for science and technology graduates to boost the economy through innovation and development, whilst on the other hand the Government has reduced funding to tertiary institutions and public research organisations in these areas (University of Waikato, 2002). This under-funding has been particularly felt in the science and technology area, where Ministry of Education funding policy has disadvantaged these subject areas because of inadequate resourcing of laboratory-based courses.

This all paints a rather gloomy picture of the science and technology scene in New Zealand. Yet there is high quality science and technology being done in the country as measured by the high publication outputs and citation rates of the practitioners (Marsh, 2000) and from my own experience of interacting with numerous science and technology employers. These conflicting views of a career in science and technology in New Zealand make it difficult for a student in science and technology to accurately assess their future prospects without some detailed knowledge of the opportunities available. The chance to undertake a work placement through a co-op degree in science and technology provides that opportunity and may reveal important career information to the student.

Therefore a co-op programme in science and technology holds the potential to make a valuable contribution to the tertiary education of future generations of New Zealand scientists and technologists. What role the work placement plays in students' learning about working in science and technology and enculturating them into the profession, and how that learning combines in a fruitful way with learning in the university context is an important area for research. This study is focused on this research area and the final section in this introductory chapter outlines how this thesis reports on this research.

1.6 Overview of this thesis

This thesis is organized into a further nine chapters. A brief synopsis of each chapter follows:

Chapter 2 reviews the literature related to cooperative education. It begins with a look at its history and spread around the world. This is followed by an examination of published research into cooperative education before focusing on issues surrounding attempts to link cooperative education to learning theory. Several learning theories that have been allied to cooperative education are then reviewed.

Chapter 3 focuses on a discussion of sociocultural views of learning and the learning context for this study. It opens with a look at learning as a social and cultural activity, leading on to a description of sociocultural views of learning and how they may be useful for theorizing about learning in cooperative education programmes. The second part of the chapter reviews ideas about the two broad contexts within this study, that of the workplace, and of science and technology. The chapter concludes with a statement of the theoretical position for the thesis.

Chapter 4 details the methodology, data collection methods and research design used in conducting the study. An explanation of how the data was analysed is provided, and discussion surrounding the trustworthiness and ethical considerations of the study follows. The chapter concludes with an outline of the design of the research conducted.

Chapter 5 begins the documentation of the results and discussion of the thesis. This chapter briefly presents data and analysis of a graduate survey that was conducted prior to the longitudinal study, which helped focused the inquiry for the interviews.

Chapter 6 presents results and discussion examining learning through work placements from a sociocultural perspective. It begins with discussion of students' learning about the sociocultural setting of the workplace. This is followed by an analysis of learning as a socially mediated, situated and participatory activity, and of learning as mediated action.

Chapter 7 presents results and discussion focusing on the significance of context for student learning. The contexts examined are the type of science and technology workplace, and the disciplines of science and technology themselves. This chapter discusses students' learning experiences related to these contexts.

Chapter 8 looks at findings that focus on the complementarity of the workplace and university settings for learning. It examines similarities and differences in student learning in these two environments, how learning is transferred between the two environments and how well learning in the two environments complement

each other. This chapter also discusses student views about assessment of their work placement.

Chapter 9 presents two case studies that describe the learning that two students underwent through their degrees and placements as they made the transition from student to practitioner in science and technology. The first case looks at a student becoming a science researcher in a public research institute, and the second case focuses on a student becoming a science and technology technician in a private commercial/manufacturing company.

Chapter 10 discusses the findings of the study and how they relate to the literature, and addresses the response to the research questions. The chapter draws these elements together into some conclusions, raises some implications from the findings and makes some suggestions for further research.

Chapter 2 Literature Review

Cooperative Education

2.1 Chapter outline

This chapter provides a review of cooperative education. It begins with a history of cooperative education programmes as it is currently understood in the literature, in order to provide a frame of reference for the significance around the world and within New Zealand of these types of learning programmes. The third section in the chapter provides an overview of research that has been conducted into co-op programmes, which provides a basis for positioning this research. The fourth section discusses issues concerning research that has previously been conducted into learning in cooperative education to provide a view of the state of knowledge regarding this subject prior to this research being conducted. The final section reviews theoretical ideas that have been explored in previous attempts to theorise about learning in cooperative education programmes.

2.2 History of cooperative education

The strategy behind cooperative education is not new. Apprenticeships and internships have existed in crafts since their very beginnings, and began to flourish in the manufacturing sector as the industrial revolution of the 1800s boosted production. In addition for many years teacher-training courses have incorporated a practicum element within schools, and doctors and nurses have been trained alongside practising professionals in hospitals. Indeed a report in the UK in 1985 into sandwich education (the British name for cooperative education) laid claim to the first such course being offered at Glasgow University in 1840 (Linklater, 1987).

However the origins of what is known today as cooperative education have been ascribed to Hermann Schneider (Cates & Jones, 1999; Heermann, 1973). Schneider was the Dean of Engineering at the University of Cincinatti in the early 1900s. He "observed that many facets of engineering cannot be learned in the classroom but only through direct on-the-job experience with professionals

already successful in the field" (Heermann, 1973, p.4). Schneider included such facets as ability to use the basic principles of science in practice, and a knowledge of means as well as matter in his original curriculum (Cates & Jones, 1999). Schneider's contribution was to champion the benefits of formally integrating university classroom education and on-the-job experience. He coined the term 'Cooperative Education' to account for the cooperation required between industry and education to educate the student to better understand the engineering concepts that he taught them at university (Cates & Jones, 1999). Schneider's emphasis on formal integration of learning between the classroom and the workplace necessitated the student spending time in both contexts and there was an expectation that learning would occur in each.

The goals of cooperative education (co-op) programmes today are to provide students with opportunities that combine learning in the classroom with learning on the job. Those opportunities require that students carry out relevant and productive work as an integral and assessed part of their academic qualification (NZACE, 1995, 2001; WACE, 2001b). It is this description of cooperative education that frames this study, and although the term cooperative education is not universally used or understood, it is acknowledged that other educational programmes such as internships, field programmes and practicums may have similar goals.

Since Schneider's innovation, growth in numbers of co-op programmes was slow, possibly due to the depression of the 1930s and World War II until the 1950s when an upsurge began in the USA (Mosbacher, 1976). Wilson (1971) reported that of 76 community colleges offering cooperative education programmes at that time, 90% had started their programmes within the last 10 years. Mosbacher (1976) professed that numbers of 'institutions of higher learning' offering co-op programmes had increased so rapidly that an accurate count was not possible, but that it was known to exceed 900.

Part of the reason for this increase was direct USA Government support for new programmes. In 1968 "federal funding ... was ensured when Congress approved certain amendments to the Vocational Education Act of 1963" (Heermann, 1973,

p.7). Over the next years successive governments extended direct funding opportunities to high schools, community colleges, and universities. This funding was essentially seed money to establish the administration of new programmes. From discussions with American co-op colleagues, it became apparent that this funding of co-op programmes came to an end in the 1990s as the USA Government felt that new programmes could be established without their assistance.

In the 1970s Mosbacher (1976) carried out a survey of cooperative education programmes around the world. She struck the problem of how to identify cooperative education. Many countries were unfamiliar with the term and although she strove to be inclusive by aligning the strategy with those known as sandwich courses, internships, professional practice, field experience, she admits that it is likely that her survey data were incomplete. Despite this she was able to report that at that time 32 countries asserted that they had programmes that fell within her broad definition.

Despite its earliest purported beginnings in the UK, it was government intervention in Britain that resulted in a concerted drive in cooperative education, or sandwich courses (Tucker, 1969). In the mid-1950s Churchill recognised that drastic action was needed to keep up with the technological advances of the Russian people. Tucker reported that 10 colleges of advanced technology were raised to university status at that time and required to have co-op programmes in engineering, business, applied science and so forth. Linklater (1987) reported, however, that by 1987 only nine out of 43 universities provided sandwich first degree courses, and it is evident that to that point the increase in co-op - style programmes in the UK had remained somewhat muted despite its early beginnings. Reasons for this are not clear but programme growth may have been held back by traditional views that universities are concerned with academic learning and not work experience, as are discussed in the next section.

However, by 1996 the Association for Sandwich Education and Training (ASET) listed 2138 courses at 120 British universities that included a component of work integrated learning or cooperative education (Association for Sandwich Education

and Training, 1996). The near-tripling of the number of universities was a result of the British polytechnics being granted university status. As these institutions had traditionally been more disposed towards sandwich education with a work component, the number of courses available at university level now appeared very high. Then in 1997 the Dearing report (Dearing, 1997) commissioned by the British Government to examine the state of tertiary education in the UK came out strongly in favour of sandwich-type education. Citing evidence of strong support from both employers and students, the report recommended that all higher education institutions should assist students to become familiar with the world of work and how it relates to their academic training through work placements. The report asserted that work experience opportunities within an educational programme would enhance the development and employability of graduates (Dearing, 1997). It is possible that this may be leading to a concerted increase in sandwich programmes, although no figures are currently available.

Programmes under the banner of cooperative education began in Canada in 1957 with the opening of the University of Waterloo (Barber, 1968). They began, as in the USA, with engineering, and have developed across subjects, across institutions and across the country. In the period 1978-1991, the number of postsecondary (tertiary) institutions offering co-op programmes increased from 21 to 85 (Cutt & Loken, 1995a).

In New Zealand a database of cooperative education programmes has recently been created by the New Zealand Association for Cooperative Education (NZACE). The second edition of the database produced in 1998 listed over 300 programmes in universities and polytechnics that offered a component of work within the qualification (Eames, 1998). The vast majority of these programmes are run by polytechnics, which traditionally have had a more applied, industry focus than universities in New Zealand. It is notable, however, that some of the more recent additions to co-op programmes in this country have been in the universities, for example at Auckland University of Technology (in business), Victoria University (in science) and Lincoln University (in applied sciences).

In contrast to the American and British experiences, the government in New Zealand has basically ignored the potential of cooperative education until very recently. The 1999 Labour Party election manifesto specifically mentioned cooperative education:

> Labour believes that students undertaking full-time study would benefit from being able to gain work experience in a workplace relevant to their course of study. What is called 'co-operative education' offers this opportunity. Labour will: build on existing examples of co-operative education to establish a pilot 'Co-operative Education Programme' (CEP) which will see students able to gain relevant workplace experience under the guidance of an approved mentor (Labour Party, 1999, website).

Since winning the election and becoming the government little action was evident on this pilot but in 2001 a Government organisation, Skill New Zealand, trialled a work placement scheme called Gateway in secondary schools. An early evaluation of the programme indicated that it was well supported by schools, students and employers and it is set for expansion in the near future (Skill New Zealand, 2002). Then in 2002 the Government contracted a student employment agency to secure summer vacation work for tertiary students that is relevant to their studies. Recent Government policy reflects these moves, stating that they aim to, "develop graduate employability through workplace experience within qualifications, and by promoting holiday work that better reflects students' skills" (Labour Party, 2003, website).

On a world scale the World Association for Cooperative Education (WACE) exists as an umbrella group set up in 1983 to foster cooperative education worldwide. It currently has membership from 39 countries although it is likely that there are also non-member countries that have programmes that practise some form of cooperative education (WACE, 2001b). It supports a biennial conference on cooperative education and is actively encouraging and supporting research projects.

In summary the cooperative education movement is currently receiving more support than at any time in its almost 100 years of recognisable history. Educational institutions, students, employers and governments are claiming its virtues and there has been a steady increase in programme numbers. Much of this impetus has been built on the current trend towards developing a work-ready graduate class that can be productive rapidly for competition in the global marketplace. This impetus is largely based on anecdotal evidence of the value and successes of cooperative education programmes, and some educators remain unconvinced of the status of cooperative education as a learning programme. Consequently amongst the co-op community there has been a drive for research evidence to support the movement. This quest is discussed in the following section.

2.3 Research into cooperative education

Although it is nearly one hundred years since Schneider is recognised as founding the discipline of cooperative education in the USA, practitioners have not yet developed a rigorously-defined academic body of knowledge about the subject. In its early years research into cooperative education was confined to the collection and reporting of anecdotal evidence. As Wilson (1989) points out "these assessments were based upon years of experience of working with and observing cooperative education students, not on empirical data" (p. 38). While it could be argued that these early practitioners were in fact collecting empirical data, it would be fair to say that the collection was not systematic, a view echoed by Finn (1997).

As Fletcher (1989) notes, the first assessment of outcomes based on systematically collected data was the Wilson and Lyons book, *Work-Study College Programmes*, published in 1961. This marked the beginning of a more inquisitive era, and in a later survey into research into cooperative education by one of the authors (Wilson, 1988), it was estimated that over 200 research projects had been completed since that book was published.

However, in the late 1990s Bartkus and Stull (1997) noted that "most of the research completed over the past 30 years is probably best described as applied-descriptive and evaluative in scope. It has been largely pragmatic in nature without a strong theoretical underpinning" (p. 9). This view is typified by the work of Auburn (1972), Dubick, McNerney and Potts (1996), Eames, Kumar, Rowe and Hitchcock (1996), Henry (1978-79), Somers (1995) and Wessels and Pumphrey (1995).

This research has helped to define what constitutes a co-op programme and has contributed much useful quantitative data to the discipline. The research has highlighted outcomes such as application of academic learning, enhanced career prospects and clarification of career choice for students; highly motivated and productive temporary employees and a preview of potential future employees for employers; and enhanced industry links and student attraction for educational institutions. These outcomes can be described as operational outcomes, being related to the general operation of the co-op programme.

Much of this research has been comparative and correlational and has attempted to find significant differences between co-op and non – co-op students on variables such as changes in academic grades, graduate salary and attitudes to work after work placements (Baker, 1975). These mainly quantitative studies have often produced inconclusive results and lacked a clear theoretical basis.

The lack of rigorous application of theory in these studies has been attacked by Ricks et al. (1990). They asserted that, "very little theory has been developed and no fine-tuning of theory has resulted from [research], discrepant and contradictory research findings have not yet been incorporated into more current research, and when research is conducted, it has usually not been formulated within a theoretical framework" (p. 11). Development or explication of theory that provides an explanation for the outcomes of cooperative education would allow practitioners to consider those theoretical constructs when designing a curriculum and pedagogy for their co-op programmes. The theory could then be explored through evaluation of practice and modified where necessary.

The same authors also criticise the research standard exhibited by those researchers in cooperative education who have published through the *Journal of Cooperative Education* (Ricks, Cutt, Branton, Loken, & Van Gyn, 1993). In particular they take issue with those who have claimed to use 'scientific methods' in their research, asserting that the collective work of these researchers exhibits few of the rigorous hallmarks of that paradigm, namely controlled studies, use of replicates and hypotheses, and an examination of causation. Although much recent research in education shuns so-called 'scientific methods' in favour of more naturalistic inquiry, the authors make the point that any methodology used to investigate cooperative education must have validity and reliability.

An example of this type of quantitative, comparative research is shown in the work of Sharma, Mannell and Rowe (1995). Their research was a study using quantitative methods to examine differences in career expectations between co-ops and non-co-ops. They used a small (70 co-op students) and unbalanced (70 co-ops to 181 non-co-ops) sample and did not appear to control for factors such as co-ops obtaining career information through their programmes where non-co-ops may not have. Their conclusions were that career-related work experience helped career decision-making but found that many co-op students had pre-degree experience, which clouded the significance of the impact that their co-op experiences had on their career expectations. The difficulty of obtaining a matched sample for comparative work in cooperative education is compounded by the variability in people and their experiences.

Some reasons for the difficulties in carrying out research into cooperative education have been offered by Bartkus and Stull (1997). They noted the difficulty of obtaining funding for research studies, the lack of graduate students undertaking research in cooperative education and the situation of the co-op coordinators/practitioners. These latter individuals, who are generally hired primarily to facilitate the placements, often have no mandate to carry out research, and, further, often lack the training to be able to do so. As Finn (1997) pointed out, a survey by Egan and Weaver-Paquette in 1993 found that fewer than 10% of co-op educators/practitioners held a doctoral degree and fewer than half held a masters degree. Bartkus and Stull (1997) went on to suggest that coordinators

should up-skill themselves, conduct research with colleagues who have skills that are useful, and look for research funding avenues.

A further complication has been raised by Ricks et al. (1990). They noted the great variability in operational parameters of co-op programmes. They concluded that "programme-specific studies cannot be generalized to other programmes unless critical programme variables are matched, e.g. student population, work terms and so on" (p. 14). This makes theorising across cooperative education only really possible at the macro-level, a difficulty that exists throughout most educational programmes.

These research difficulties have hindered the ability of the cooperative education community to develop a theoretical foundation for their form of education. The lack of recognition of cooperative education as a discipline worthy of study may have been due in part to the apparent successes of programmes at an operational level. As co-op graduates got jobs, then the perception could be held that the programme was working. But what of the learning that was achieved by the students in their workplaces? Co-op programmes are educative by name and design, and therefore learning should be a goal of all elements of those programmes, including the work placements. It is important therefore to work towards a clear understanding of student learning through work placements so that pedagogical and curricular issues can be addressed, and to understand how that learning can be integrated with classroom learning to provide a programme acceptable to educators and administrators.

The next section examines issues research into learning in cooperative education.

2.4 Issues in research into learning in cooperative education

As noted above, there has been a significant body of research that has pointed to the potential for operational outcomes achievable through cooperative education. What has been more difficult to ascertain are the educational outcomes from work placements (Ryan et al., 1996; Van Gyn et al., 1997). This difficulty has led to a paucity of knowledge about learning in the work placement. This section

examines the issues surrounding research into learning in co-operative education, which are addressed as legitimisation, methodological and theoretical concerns.

2.4.1 Legitimisation

Concern for legitimisation of the role that learning on placement plays, and understanding how it occurs in a co-op programme has been prominent in the literature for many years. In Wilson's view "we rely too much on student papers about their work experiences and on employer ratings in order to award credit and we spend too little effort finding out what the students are really learning so that we can effectively guide them in their further learning efforts" (Wilson, 1989, p. 42). It may be better to try to 'get inside the heads' of the students in order to explore their perceptions of their learning. Most co-op practitioners would readily agree that students do learn while on placement (Dawson, 1980-81; Gordon, 1976), but there is a poor understanding of what they learn and, even more so, how they learn.

Further to these concerns is the observation made by Wilson (1973) that many institutions award degree credit for work experience conducted as part of a cooperative programme. He argued that it is important that credit is not simply given for work experience, but that it is given "for learning resulting from work experience" (p. 36). As such it is important to educators that learning through work experience is understood so that it can be appropriately assessed.

It was this concern for assessment and legitimisation of learning on work placements that led the USA Government in the late 1970s to commission a study into educational outcomes and their assessment in co-op programmes (Wilson, 1980-1981). This study surveyed large numbers of students, employers and coordinators about educational objectives that could or should be incorporated into programmes. The researchers identified 72 learning objectives that could be achieved through cooperative education, and a larger survey of the use of these 72 objectives allowed them to identify the most common and categorise them into groups. They used these groups to determine four areas of endeavour that could be tested as assessment for work experience. They noted the need for context-

specific objectives that could be related to the professional context of the student's placement; that the objectives be of an appropriate complexity for the student's level of study; the need to be able to accurately measure attainment of objectives (which presented problems in considering difficult-to-measure objectives such as learning about the world of work); and the need for criterion-referencing against expected competency levels to allow assessment fairness. It was hoped that such a system could allow equitable and accurate assessment of student learning across a diversity of work placements. One issue they hoped to address was the academic value that could be ascribed to work placements, particularly for students who wanted to transfer their academic credits between institutions. It is uncertain what the outcomes of this work were as no mention is made of them in the subsequent international literature.

So how can a co-op programme take heed of the context in which a student learns in the workplace, contain criteria for assessment that are relevant and appropriate, and include the more difficult-to-assess items such as learning about the world of work, which are potential outcomes of a work placement as described by Wilson (1980-1981) above? This still remains a key issue for co-op practitioners and is a focus for this study, and although an in-depth treatment of assessment in co-op is beyond the scope of this thesis, it will remain a part of this investigation of student learning.

A number of other authors have addressed the issue of learning objectives and outcomes and argued for their importance. Garmon and Strandberg (1976) elaborated a process for setting objectives and measuring outcomes, which they had found to be very successful in their programme. Laramee (1972) stressed the importance of guided reflection through a process of educational debriefing on learning objectives to enhance a student's own understanding of their learning outcomes. Dawson (1976) on the other hand, although viewing the setting of objectives as important, abhorred the trend at that time towards using the objectives to measure learning, advocating that some of the most important student learning cannot be accurately assessed.

Contrary to these views are those of Page (1980-1981) who argued that cooperative education is an inductive process, placing the emphasis on student responsibility to learn, whereas learning objective methodology is deductive, and the responsibility for learning rests with the teacher who decides what shall be learnt. Page's idea was to use expressive outcome methodology, in which "the student is required to extract (and express) academic insights embedded in professional practice" (p. 41). He argued that this formal acknowledgement of the integrative process of cooperative education, and its linkage to assessment would ensure academic soundness in the co-op programme. While this approach has merit in emphasising integration, in practice students require guidance in learning, and it risks ignoring other learning that could be entirely valid but not integrative, as the variability of work placements may provide other opportunities to learn which may not be easily related to what is learnt in the classroom. This may include the social sharing of information amongst colleagues at work, or the need to be dressed appropriately when working with the public.

Some evidence for learning outcomes has been cited by Williams (1991) in his survey into research in the experientially-related area of field education, which focuses primarily on secondary schools. In a quantitative, correlative study he noted that there appeared to be no detriment to academic achievement to those students who participated in field education compared to those who hadn't, despite comparatively less time in traditional classroom learning. (Conversely it was inconclusive as to whether field education was an advantage to academic achievement). Williams (1991) noted learning benefits reported by field-educated students as interpersonal and intrapersonal skills, attitudes towards school and learning, and career awareness. In a critique of Williams' survey, Fletcher (1991) acknowledged the similar outcomes reported from co-op research and the common ground that exists between a number of experiential education disciplines. She cautioned however that diversity of students, programmes and types of experiences must be heeded if assertions are to be made about outcomes, and that research that seeks not to compare participants with non-participants, but to understand how outcomes are achieved would be most useful. There is merit in Fletcher's (1991) view, as it moves away from the traditional academic against vocation debate that has plagued support of cooperative education. This debate

has centred on whether the placement can be viewed as an 'academic' learning component, and whether it should be incorporated into a qualification, particularly at university level.

This debate has led co-op practitioners to believe that they must legitimise co-op programmes as academic learning programmes. In their assessment of the Canadian co-op system, Cutt and Loken (1995a) concluded that evidence:

> "suggests that cooperative education is a socially beneficial enterprise [that is, its benefits exceed its costs] and should be actively pursued. But for faculty and administrators in universities whose decisions to offer cooperative education are essential, the evidence on the benefit side is very thin, particularly in the critical area of educational (academic learning) benefits that legitimize cooperative education as an educational enterprise within universities" (p. 107).

For example, elsewhere the same authors note that at their institution at a time of tight budgets, "cooperative education programmes were grouped with other 'administrative support services' and subjected to a significant budgetary reduction; 'academic' budgets went unscathed" (Cutt & Loken, 1995b, p.37). These difficulties have stemmed from a view that the act of placing of co-op students within workplaces is not an academic exercise, and the completion of the placement by the students is not educative, in the academic learning sense.

As Van Gyn et al. (1997) point out, the traditional view is that cooperative education is an effective training strategy rather than an educational strategy. This view implies that co-op is a vehicle for training students to perform certain tasks in certain jobs, rather than the more generalist knowledge/skill accumulation and development of thinking assumed to be the domain of education, particularly in the university sector.

This thesis argues that such a distinction between learning on placement and learning in the classroom is unhelpful and irrelevant to understanding learning in

co-op programmes. What is more germane is to consider the learning that does occur through co-op placements and how it complements the classroom learning. Enhancing our understanding of this placement learning and its integration with classroom learning could remove administrative and political objections to the value of co-op placements.

2.4.2 Methodological approaches

The second concern regarding research into cooperative education that has emerged more recently is methodological. As discussed in Section 2.3, this revolves around the researcher's choice of methodological approach. This can broadly be described as either quantitative and positivist, or qualitative and interpretive. These different approaches are discussed more fully in Chapter 4 but briefly the former relies on posing a hypothesis which is then proven or disproven through collection of large amounts of data, which are analysed statistically for correlations or causality. The latter method involves a close association between the researcher and the researched in which subjective meaning of data is interpreted by the researcher.

Early research into the educational benefits of co-op by practitioners (e.g., Lindenmeyer, 1967; Smith, 1965) has been criticised as being too descriptive or for having failed to control for dependent factors such as student ability at entry to the programme (Van Gyn et al., 1997). Most of these studies have attempted to apply quantitative survey techniques and educational achievement instruments, which, whilst providing some indicative data, have failed to control for the diversity of different programmes and work placements within programmes, whilst claiming to be scientifically methodological. They have also tended to concentrate on using changes in academic performance such as grade improvement as an indicator of educational benefit, often comparing co-op students with those who have not undertaken a co-op programme.

An example of such research is a recent study, on an ambitious scale, which sought to examine learning in a longitudinal way, by determining whether participation in a co-op programme made any difference to the academic progress

of the students in that programme (Van Gyn, Branton, Cutt, Loken, & Ricks, 1996; Van Gyn et al., 1997). The research was grounded in the model proposed by Branton et al. (1990) that emphasised the interaction of the learner with learning experiences both in the educational institution and in the workplace.

Attempting to learn from the errors of past research noted above, Van Gyn et al. (1996) controlled for entry-level academic differences in their comparison between co-ops and non-co-ops. Their assessment of entry-level differences between the two groups was based on an instrumental test of ability to apply general knowledge and skills relevant to adult society, and quantitative analysis of results. The results found two variables where small but significant differences showed between the two groups: academic preparedness and prior work experience. Accounting for the first of these, the authors admitted that in the two programmes used in the study, as in many others, academic selectivity is practised for entry into a co-op programme therefore it is not so surprising that co-op students were seen to be academically superior at entry. This would obviously need to be taken into account in any comparative study of academic progress, a factor also alluded to by Wilson (1987) and Rowe (1989) in co-op research. In the second variable, cooperative education students had surprisingly more, and more relevant work experience than non-co-op students at entry. The authors were unable to suggest reasons for this factor, but their work shows that previous work experience would also need to be taken into account in investigations of learning on co-op placements.

Having established these entry differences, the researchers re-tested the participants 26 to 31 months later after all participants had attended university for an equal number of academic terms, and co-op students had completed work terms. Rather surprisingly they discovered that after nearly three years of university education, mean test scores on the general knowledge and skills instrument had decreased for both co-op students and non-co-op students, indicating a loss of knowledge and skills. This led them to doubt the validity of their test instrument. They did however find a significantly greater mean test score using the same adult general knowledge and skills instrument after the university study in the co-op students than in the non-co-op students. This

increase in learning of knowledge and skills relevant to adults led them to a tentative conclusion that co-op experience may enhance that learning (Van Gyn et al., 1996).

This was a rigorously planned, well-controlled study and yet it still failed to deliver any significant data to back up claims for educational benefits of cooperative education. As Van Gyn et al (1997) admit, their study looked only at knowing that, and not knowing how. They also showed that a well-designed measurement instrument administered with care may yet give surprising and perhaps inaccurate results, leading them to conclude that "the more in-depth and specific results gained from a variety of qualitative methodologies may be of more value to us in examining our current programmes and designing new programmes" (p. 83). The data collection techniques and data analysis more suited to the qualitative approach may prove better at detecting educational benefits.

A second example of quantitative, comparative research into cooperative education placements focussed on the development of practical intelligence and tacit knowledge through co-op work experience (Williams, Sternberg, Rashotte, & Wagner, 1992). Williams et al. (1992) used their own beliefs that tests of tacit knowledge are useful in "measuring the products of informal experiential learning" (p. 33) to design a quantitative, comparative study. They used a moderate sample size of co-op students and non-co-op students and administered several research instruments (questionnaires). The results of the study showed some minor differences between the groups in development of what they termed practical intelligence (see Section 2.5.5). While this study has merit in illustrating one mechanism for assessing tacit knowledge in cooperative education students, one omission appears to be a failure to recognise any work experience that the co-ops may have had prior to undertaking their co-op placements. This potential entry-level difference could have had significant effects on their data, as Van Gyn et al. (1996) discovered in their study above.

As these examples show, much of the research into the outcomes of cooperative education have been conducted in a positivist/quantitative manner, and that whilst

they have produced some useful data, there are questions still to be answered. This is particularly in relation to the educational outcomes as these are seldom the result of a single factor. The complexity of the learning experience in co-op placements has made it difficult to generalise in a manner that positivist researchers would like. There exist differences amongst co-op programmes in the way that placements are organised, how they are run, the types of employer organisations that are involved, the length of the placement and the educational objectives of the placements. Not only are the educational outcomes very difficult to research and apply across co-op programmes, the case for understanding the learning process in co-op placements through positivist means is even more dire. There is now increasing recognition that qualitative methods of inquiry may reveal a richer vein of data about the students' experiences in the workplace. These methods may provide an insight into the student's construction of the reality of the workplace and how they experience the world. This knowledge would be valuable to co-op practitioners in considering appropriate pedagogies and curricula for co-op programmes.

One recent proponent for the use of qualitative methods in co-op research was Kathleen Finn (Finn, 1997). She asserted that if we view cooperative education as a human study, then methods of knowing may need to change from the empirical scientific (positivist) paradigm to more, "qualitative methods of inquiry that involve the study of perceived reality to gain understanding of that reality" (p. 40). This would allow co-op educators to delve more deeply into the phenomena that underpin co-operative education such as experience and repetition. Finn called for research into the phenomenon of experience, which she argued underpins cooperative education. Importantly, this would allow the student voice to be heard, something that is missing from earlier research. Finn supported the importance of understanding the student's experience believing that the role of co-op practitioners is to interact with "students to uncover the meaning embedded in the student's co-op experience" (Finn, 1997, p. 41).

There have been a few co-op studies published that have used qualitative inquiry. One of the first published research studies into learning in work experience programmes was by Hagerty (1980-1981). She used ethnographic techniques

because "it is believed an ethnographic approach will offer the greatest insight into the experience from the intern point-of-view" (p. 28). She was particularly concerned with locating the study in the cultural context of the students' experience, and used questionnaires, interviews, participant observation and student journals to investigate this. She used as a basis for her study Coleman's (1976) ideas about experiential (outside the classroom) and assimilation (within the classroom) processes. Hagerty's (1980-1981) findings led her to conclude rather broadly that her study showed that co-op gave interns experience outside the classroom, which complements and enhances their academic studies. Hagerty (1980-1981) asserted that there was synergy with Coleman's theory of experiential learning in the students' experiences in that students were " forced to act, monitor consequences, and learn phenomena" (p. 38). This could now be regarded as a pioneering study and one that has led the way in qualitative research into cooperative education, and the paradigm of constructed social realities.

Since 1990 a number of studies have been published which have focussed on student experiences and perceptions of their learning through cooperative education using qualitative inquiry.

A major Australian study at the Queensland University of Technology into students' perceptions of what they learn from a co-op work placement revealed a plethora of identified outcomes (Gardiner & Singh, 1991). The authors interviewed and surveyed students, employers and academic staff about their views of the cooperative education programme. The perceived outcomes for the students from their study have been neatly summarised by Trigwell and Reid (1998):

> Students believe that they learn to use equipment that is not available at university, that they are involved in entire research project/programme development rather than piecemeal technical skill development, and they get a chance to become involved in complex problem solving. On a personal level they learn interpersonal skills, written communication skills, time management, develop increased confidence, and have a better

> knowledge of career opportunities. They view learning as occurring (at work) through one-to-one learning with an expert/professional, through collegial relations with work staff, and through a process of picking it up as they go along. They believe this learning has immediate relevance, and note among their reasons for their involvement in work placements: increased employment prospects, clarification of their career path, practical experience to supplement theoretical studies, work experience to add to their resume, the chance to gain financial independence, and as a break from study (p. 151).

This is an impressive list of learning outcomes but this study does not provide any help in understanding the learning process. Gardiner and Singh (1991) conclude their book with recommendations that theories of learning, social interaction and cultural interaction be used to examine student experiences of cooperative education, and that the contexts of the transition between university and the workplace be researched.

A small number of other studies have been published over the past 10 years, which have looked at learning in work experience placements using qualitative research methods. These have included the use of focus groups to investigate 'contested learnings' – "outcomes that suggest ambiguity and conflict between what is espoused and what is practised in either the workplace and/or the university or college classroom" (Schaafsma, 1996, p.6); the use of a case study approach to examine learning processes adopted on placement (Eakins, 1997); the use of questionnaires combined with focus groups to look at student perceptions of learning (Keay & Lee, 1998); the use of interviews to gain graduates' perceptions of the importance of their co-op experience completed 50 years ago to their careers (Linn, 1999); and the use of participant observation and interview to study what is learnt and how it is learnt on a co-op placement from a curriculum perspective (Munby, Chin, & Hutchinson, 2000).

In summary there has been a recent movement amongst cooperative education researchers away from quantitative studies in the paradigm of positivism that

views reality as objective. There is also a realization that comparative studies between those students who undertake work placements and those who don't are fraught with difficulty and have often produced inconclusive results. The focus in co-op research has moved towards the student and their experiences, and this has led to a change towards more qualitative methods of inquiry, in the paradigm that views reality as more subjective. In concert with this move, has been a genuine attempt to try to understand the learning that a student undertakes while on placement. This has been driven partly by a perceived need within the co-op community to legitimize cooperative education, viewing work placements as an educational strategy with a theoretical underpinning. This issue is discussed in the next section.

2.4.3 Theoretical frameworks

The failure to gain clear recognition of work experience components as learning opportunities has been linked to a failure thus far to place cooperative education on a sound educational basis with a theoretical underpinning. There have been increasing calls, for example, by Ricks et al. (1990), that for cooperative education to be credible as an educational practice, it should be related to a theoretical framework of education and educational goals.

An attempt to do just this led Jabs, Jabs and Jabs (1978) to argue that cooperative education should address goals arising from several different educational philosophies including that of the pragmatism suggested by Dewey and others (learning by doing), essentialism (acquisition of knowledge and skills) and competency-based education (ability to carry out tasks), and that each programme should seek to justify goals and outcomes on the basis of appropriate philosophies. This early approach acknowledged the complexity of co-op programmes and advised flexibility to adopt a philosophy that fitted the programme context. These authors recognised the importance of context but offered no theoretical framework for learning on placements.

Developing a conceptual framework to account for learning outcomes from experiential learning events and a concern for how to measure them led to the

creation of a group to look at the Cooperative Assessment of Experiential Learning – CAEL in 1974 (Gordon, 1976). The emphasis on measurement again here suggests that a view of learning that was rooted in positivism underpinned the study. According to Gordon (1976) this group published many working papers on the subject of learning in the work placement. However, she did not elaborate on the contents of these papers and there is no mention of this work in later co-op literature, so it appears that its impact was minimal on the co-op community. Copies of the working papers were unobtainable.

In 1985 the Cooperative Education Association of America (CEA, now CEIA – incorporating Internships) commissioned a committee to report on the location of cooperative education within the mainstream of American higher education. They were concerned that despite the obvious growth and success of co-op, the discipline languished on the periphery of academic endeavour (Heinemann, 1988). The committee's report reflected this view and suggested three main reasons for this:

1. Faculty do not recognize work as a vehicle for learning and, in fact, view cooperative education as '*anti-intellectual*' (original emphasis);
2. Co-op practitioners tend to see themselves as operational people concerned with logistics and administration – not as educators;
3. Cooperative education methodology for promoting learning is vague and underdeveloped (as summarised by Van der Worm (1988).

On the strength of the committee's report, the CEA committee made four recommendations:

1. Conduct more research into learning outcomes that takes heed of cognitive psychology, skill acquisition and enlists the aid of researchers from a variety of disciplines such as psychology, sociology and education, so as to be exposed to a variety of theoretical views;
2. Develop criteria for programme quality, standards and ethics;

3. Develop professional development programmes for co-op practitioners that enhance their teaching and counselling skills, and their understanding of human development in work situations;
4. Expand dissemination of information and research on cooperative education (Heinemann, 1988).

These recommendations found favour with Branton et al. (1990) but in addressing the first point, these authors argued that more research of itself would not help: the research needed to be "placed in the context of contemporary learning theories" (p. 31). An alternative to this strategy would be to generate theory from research into co-op practice as suggested by Ricks et al. (1990).

Branton et al. (1990) developed a model of education that built upon work by Robert Gagne (Gagne, 1977). The model allied Gagne's internal and external conditions of learning with an adaptation of Foster's (1986) principles of learning, which in turn had been based on educational theorists such as Ausubel, Bandura and Thorndike among others. Branton et al. (1990) argued that research should be directed to show "whether cooperative education practice supports the application of the learning principles better than other modes of educational practice" (p. 36). It might even be possible to use such a model to credentialise co-op programmes that meet the principles to varying standards. This model had merit in combining various ideas about learning, but as the authors state, required empirical evidence to justify its efficacy in accounting for learning in practice. As yet there has been no evidence in the literature for such research having been done, and contemporary learning theorists have moved away from Gagne's ideas about conditions of learning.

Despite these clear calls for research into learning in co-op placements that would support cooperative education pedagogically and politically, a recent survey of North American co-op practitioners by Stull, Crow and Braunstein (1997) found that the practitioners believed the greatest need for research into co-operative education was that which "identifies and evaluates the kinds of learning outcomes attained by students who participate in co-operative education programmes" (p.

32). This seems to indicate that in the 10 years since the CEA report, their recommendations had seen little attention in the USA.

It seems that co-op practitioners do not yet have at their disposal sufficient information to give them confidence in the pedagogical planning of their programmes, or to allow them to argue conclusively for cooperative education to be seen as a legitimate and valuable form of education. The evidence available from learning outcomes studies has not sufficed and the need for theoretical backing is still apparent.

Cates and Jones (1999) have recently summarized what they see as three important benefits that result from taking an academic approach to cooperative education: student learning is optimised through conceiving the work placement as a learning experience that is pedagogically planned; clear learning goals linked to a curriculum could be defined and assessed in placements, and co-op programmes can enhance the educational standing of the institution. The authors go on to explain what they believe are the components of an academic approach including establishing learning goals, use of a curriculum, appropriate assessment of learning and links to academic faculty. These components would be based on a theoretical framework of learning.

So what theoretical perspectives could possibly help to explain learning in cooperative education? Some genuine attempts have been made to theorise about learning in co-op by linking the discipline to a variety of ideas. The following sections discuss these ideas and the promise they hold as a theoretical basis for cooperative education.

2.5 Theoretical positions linked to cooperative education

This section reviews some of the main theoretical positions that have been suggested as useful for understanding learning in cooperative education.

2.5.1 Behaviorist view of learning

One view of learning to which cooperative education has been linked is the behaviourist tradition. Behaviourists believe that in order to be able to state that learning had occurred, a change in behaviour must be able to be observed in the subject (LeFrancois, 1988). A study of learning in the behaviourist view focuses on the external conditions that influence the behaviour and how behaviour is modified by its consequences (Mowrer & Klein, 1989).

In the early part of the 20th century psychology researchers such as Pavlov, Watson, and Guthrie focussed on animal behaviour and developed their ideas of a stimulus-response association and reinforcement (Mowrer & Klein, 1989). LeFrancois (1988) provides an overview of the development of the behaviourist view of learning: Pavlov was a Russian physiologist who developed notions of stimulus–response learning in experiments with dogs. His work influenced an American psychologist, Watson, who coined the term behaviourism to explain the scientific study of observable behaviours, brought about by stimuli. Guthrie further developed this idea to view learning as formation of habit, the links between the stimulus and the response. Then psychologists such as Thorndike and Skinner suggested that learning occurred through experiencing the effects of behavior on stimuli, known as reinforcement. These researchers experimented with cats, dogs and other animals and found that they would learn to respond to a particular environmental stimulus. Some of these researchers such as Hull and Thorndike, also began to test their ideas on humans (Amsel, 1989). Later researchers such as Tolman added notions of expectancy and goal-directed behaviour, and Skinner built on ideas of reinforcement from Thorndike and Hull to propose that learning is based around the environmental response to behaviour (Mowrer & Klein, 1989), and developed the idea of behaviour modification.

Educationalists adopted these views of learning from the psychologists. The behaviourist tradition dominated education in the first half of the 20th century (Duit & Treagust, 1998). Indeed cooperative education was founded in the USA during the development and prominence of the behaviorist view and so its influence on co-op would be expected. There appears to be no direct evidence of

an explicit link between learning in cooperative education and behaviorist ideas. But it is clear from the literature that some co-op writers may have been influenced by this way of thinking. For example, one of the most prominent co-op writers of the 1970s and 80s, James Wilson, wrote that the nature of education "is a process of changing behaviour (broadly conceived) through experience" (Wilson, 1973). Richard Wilson from the influential USA co-op institution, Northeastern University, also wrote that education involves changes in behaviour, but also in thinking, signalling a move towards acknowledging the role of cognition in learning (Wilson, 1980-1981). As already noted above, previous studies into how to assess learning in co-op placements were couched in terms of measuring achievement of objectives rather than assessing learning, indicating a more positivist/behaviourist approach to learning (Wilson, 1973; Wilson, 1980-1981).

Behaviourists did not consider the mind and thinking in their explanation of learning. However, as education and psychology researchers moved more into studying human learning they found difficulties with this approach. Capacities such as concept formation and problem solving could not necessarily be observed as behaviours and it was recognised that they may reside within the mind and not be demonstrated by the body (Mowrer & Klein, 1989). More recently Bandura's (1977) ideas that learning can be vicarious, resulting from observations of others in a learning-by-example mode, have also served to diminish the widespread applicability of the behaviourist paradigm to learning.

By the middle of the 20th century Gestalt psychology began to emphasise perception, insight and meaning, and that learning involved an individual reorganising sensory stimuli in the mind (Merriam & Caffarella, 1999). Technological developments such as the study of artificial intelligence and other changes in the fields of linguistics and anthropology led to the establishment of cognitive psychology (focussing on the use and handling of information by the mind) as a discipline (Sternberg, 1999). Thus began the so-called 'cognitive revolution' whose adherents argued that human learning could be explained through cognitive processes. The discipline of cognitive psychology developed largely in response to critiques of the behaviourist paradigm.

From an educational viewpoint, the behaviourists emphasised the acquisition of skills and knowledge that underpinned those skills. In this sense this view of learning is a useful way of conceiving of simple skill development, and could explain this type of learning on a co-op placement. The cognitivists on the other hand emphasised cognitive development, the conceptual structures of subject-matter disciplines, and strategic information processing (Greeno, 1998). Co-op placements offering opportunities to learn more than just simple skills would need to examine the cognitive view of learning to explain how learning could occur.

Although there remain many proponents of the role of behaviour change in learning, and some that combine behavioural changes with cognition in their ideas, it is fair to say that cognition has become the dominant approach to understanding the working of the human mind and the process of learning. One of the key early theorists in the cognitive field was Jean Piaget. Piaget's ideas have been allied to a student's development through a co-op placement and are discussed in the following section.

2.5.2 Piaget's developmental theory and constructivism

Piaget was a Swiss-French biologist who later moved into the realm of psychology in the early to middle part of the 1900s. Amongst other studies, he made a close study of his own children's intellectual development that became the foundation for his theoretical work. His ideas can be broadly categorised as Stage Theory, Cognitive Development Theory and Constructivism.

In the first of these ideas, Stage Theory, Piaget developed a four-stage theory of cognitive development to explain the intellectual progress of his children. The theory suggested that intellectual development could be viewed as passage through four stages in which cognitive ability is successively more developed. This Stage Theory is now largely challenged by educationalists on the grounds that children are not as egocentric (unable to assume another's perspective) as Piaget had claimed, but that they also have a social dimension of concern, and that they are more able to reason deductively and learn language than Piaget had

thought (Donaldson, 1979). Further Carey has argued that children and adults in fact think alike, in opposition to Piaget's thinking, but do differ in domain-specific knowledge, in agreement with Piaget (Carey, 1985), and that children rather have 'alternative conceptual frameworks' of phenomena (Carey, 1986). Others have challenged Piaget's assertion that there exists a single route of intellectual development (Sternberg, 2000) and suggest that development is more continuous than discrete (Gardner, 1983).

The only area of Piaget's Stage Theory that is useful here is the consideration of his espoused last stage in intellectual development. Piaget called this the formal operations stage. He saw this stage as occurring from the age of 11-12 years and stretching into adulthood, and therefore is relevant to our discussion as most students at tertiary level are young adults. Piaget characterised thinking development in this stage "as the ability to think beyond the present and form theories, to reason in a hypothetico-deductive manner" (Piaget, 1950, p. 148). This requires a level of reflection about experiences, and contributes to ability to solve problems. It may be that exposure to novel experiences through co-op work placements could enhance these abilities and therefore improve learning capacity. However there has also been criticism of the notion of the formal operations stage, based on empirical evidence that some individuals do not display the type of thinking that Piaget's formal operations stage would predict, and that domain-specificity is important in cognitive development (Pintrich, 1990).

Piaget further proposed a Cognitive Development Theory for development of logical thinking. His basis was that individuals construct their own meaning from their experiences and carry out three processes in learning: assimilation, accommodation, and equilibration (Piaget, 1950). Assimilation is the incorporation of new experiences into an existing mental framework; accommodation is the development of an altered mental framework to account for new experiences; and equilibration is the process that occurs as the individual adapts to its new mental position, and is a balance between assimilation and accommodation (Piaget, 1950). This theory places the emphasis on action, that individuals seek to understand their experiences with their world, and introduces

the notion of conceptual development as distinct from concept transmission in the learning process.

Cates and Jones (1999) have looked to the cognitive development ideas of Piaget for relevance to cooperative education. They noted that students could be viewed as undergoing assimilation, accommodation and equilibrium (note: Piaget's term was equilibration) through their work experiences, and saw the equilibrium process as the most powerful force for learning. They argued that co-op students benefit greatly from developing logical reasoning strategies in the classroom and in the workplace, such that when they move subsequently, upon graduation, into the work place, their equilibrium is less disturbed due to the opportunities they have had to assimilate and accommodate to that type of environment, in contrast to those students who have not had work placements.

Piaget's most enduring contribution to understanding learning appears to be his thinking on what has become known as Constructivism. He believed that through processing information about the world by assimilation, accommodation and equilibration, an individual was able to develop mental constructions about the nature of the world, and develop more complex understanding and reasoning. Whilst constructivism has become well-supported by educationalists (see Sections 3.2 and 3.5.1), critics have pointed to a number of flaws in Piaget's conception of it (Bell & Gilbert, 1996; O'Loughlin, 1992). These critics see Piaget's model as assuming that there is an objective world that all individuals can come to know, that there is only one route in the developmental process, that development involves making "content-free logical structures and operations" (Bell & Gilbert, 1996, p.45), that construction does not take into account social and historical factors of knowledge, and that the process of knowledge construction is seen as personal, and tends to overlook social influences. These critics argue that Piaget's model does not fully explain learning in a world influenced by sociocultural and contextual factors (O'Loughlin, 1992) and that it espouses coming to know an objective world in order to adapt to it, rather than allowing for any change to that world.

While his focus was on the individual, Piaget did acknowledge that context and social factors did impact on learning. He viewed intelligence as "a process of active adaptation to the physical and social environment and all intelligent acts presume underlying 'structures' that develop in an organized, inter-related manner. Intelligence develops and knowledge results through active intervention with one's environment" (Good, Mellon, & Kromhout, 1978, p.688). It has also been argued that Piaget clearly acknowledged the role of social interaction in development in children (DeVries, 1997), in a view that focuses on the place that social cooperation has in learning. This is seen to allow exposure of the learner to different points of view, but that construction is still done individually (Driver, Asoko, Leach, Mortimer, & Scott, 1994).

Piaget's ideas have had an enormous influence on educational theory and vast amounts of research have been conducted to explore and replicate his ideas. Many of his ideas have been criticised as not allowing for representation of the influence of sociocultural situatedness in development of knowing and understanding. This thesis will argue that learning through work placements is critically influenced by sociocultural factors and that how a student learns about practice in science and technology through those placements is constrained and enabled by the sociocultural context in which they work. As such whilst Piaget's work is acknowledged as a foundation of the useful idea of constructivism, his theories do not appear to satisfactorily explain learning through cooperative education.

2.5.3 Experiential learning theory

During the mid-1900s Jerome Bruner was working on similar Piagetian-type ideas of cognitive development in the USA (Bruner, 1966). Around his work grew a movement of experience-based instruction that contributed to the emergence of an experiential view of learning (Kolb, 1984).

Experiential learning theory seeks to explain the role that experience (direct personal participation, observation or sensing) plays in learning. It focuses on how learning may occur through the provision of curricular elements that allow students to experience the world around them. In this way there is a direct,

personal encounter with phenomena being studied and not just thinking and talking about them (Kolb, 1984). Kolb has defined learning as "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p. 38).

It is clear that experiential learning ideas should have relevance to cooperative education, a discipline distinguished by its experiential component. Indeed co-op practitioners have looked to the ideas of John Dewey and David Kolb in particular to explain how students learn through work placements. The following sections discuss the ideas of these two proponents, and how they have been allied to cooperative education.

2.5.3.1 John Dewey

Dewey was an American who wrote extensively about experience and education in the first half of the 1900s. He has been characterised as an educational philosopher (Campbell, 1995). His philosophy has been described as pragmatism, in that people need to see the point of their education in order to learn effectively and that knowledge is valued for what you can do with it, not just for itself (Sternberg, 1999). Dewey saw experience as the sum of interactions between a person and his or her environment (physical, emotional, social and cultural). He viewed experience as complex and distinctively human, and insisted that it should be seen as containing both the content of what is experienced, and the process of how things are experienced (Campbell, 1995). He also saw that reflection was a part of education, and that education should not merely be seen as preparation for a vocation (Boisvert, 1998). Dewey espoused a laboratory model of education in which experience evolved into learning, and in which the artificial dualism of academic and vocational education is eliminated (Heinemann & DeFalco, 1990). He advocated a connection between theory and practice that created meaning for students in their learning and led them to further experiences (Dewey, 1916).

Dewey believed learning occurred through observation of one's environment (physical, social and cultural), knowledge of what has gone before, and judgement combining the observation and the knowledge, leading to purposeful action

(Dewey, 1938). He saw the postponement of immediate action due to experience, based on impulse, as necessary to allow an educative process. In this model Dewey focuses on behavioural change rather than cognition, in line with the prevailing view of learning of that time. It has been argued that Dewey held a constructivist view of knowledge and a behaviourist theory of meaning (meaning constituted through social interaction, mediated by behaviours, particularly the use of shared language) (Garrison, 1994). In this view, meaning is socially constructed through socially-shared behaviours such as language. Dewey saw that experience was a transaction between a person and their environment, and that for experience to be educative, it needed to be actively interpreted by the experiencer and placed within the framework of their current knowledge (Geiger, 1958).

Critics of Dewey's ideas have found deficiencies in his notion of reality in which he has been seen to over-emphasise the role of experience in framing reality (House, 1994). But it has been further argued that context has a strong bearing on the pragmatist view of reality (Cherryholmes, 1994), and that Dewey understood the importance of context, being understood for the purpose of this study as the conditions under which learning takes place.

Dewey's championing of the role of experience in education has naturally led co-op educators to examine the views that Dewey held for theoretical usefulness with cooperative education. Branton et al. (1990) note that the Wilson and Lyons study of 1961 may have been the first published attempt to link co-operative education with educational theory, by relating co-op practice to the educational theories of John Dewey, linking experience and learning, and this linkage has since been explored in more detail in the literature.

Jabs et al. (1978) argued that co-op programmes fit the pragmatist philosophy well. They described co-op programmes as experience-based and emphasised Dewey's view that experience is important to the learning process, and that the learner understands reality through their experiences. Heinemann and DeFalco (1990) pointed out that adoption of Dewey's laboratory model of higher education through cooperative education could result in a "more broadly educated populace that is so critical to sustaining a democratic society" (p. 43). As noted earlier, this

model opposes the traditional dualism of vocational and academic learning and seeks to blend them where experience evolves into learning, equipping the learner with the tools to face new problems as they arise in their world.

Importantly for co-op practitioners, Heinemann and DeFalco (1990) reiterated Dewey's concern that not all experiences are educative:

> The belief that genuine education comes about through experience does not mean that all experiences are genuinely or equally educative. Experience and education cannot be directly equated to each other (Dewey, 1938, cited by Heinemann & De Falco, 1990, p. 13).

They stressed that following Dewey's ideals means that provision of appropriate experiences and guidance of the student is necessary through their work experience to help them make meaning of that experience. They believed that Deweyan philosophy gave several clear implications for cooperative education:

1. Co-op programmes should include but not be limited to career-relevant objectives. Their focus should not be so narrow as to prescribe the students to a particular career. For example students should be encouraged to consider undertaking a range of experiences when considering career options.
2. Co-op programmes should encourage reflection in the learner with an interdisciplinary perspective. In other words the student needs to be able to reflect on their work experience from a variety of viewpoints.
3. Co-op programmes should allow the student to examine the relationships between theory and practice in the workplace. For example how are concepts learnt in the classroom employed in the workplace, and how are methods learnt in the university laboratory adapted in the workplace. {Note: learning methods often involves learning the concept behind them}.
4. Co-op programmes should ensure that the experience is educative. The programme should provide the student with the learning skills and knowledge to gain the full learning potential from their placement (Heinemann & DeFalco, 1990).

These points are well made and ideally should be found in the goals of all co-op programmes. What Heinemann and DeFalco (1990) did not specify so clearly is that Dewey's philosophy underpins the notion of lifelong learning, a concept that rose to prominence long after Dewey alluded to it, and one that shares tenets such as reflection and theory/practice relations with cooperative education.

Furthermore, Van Gyn (1994) proposed a transaction orientation for cooperative education that has links to the ideas of Dewey and Piaget. Central to this orientation "is the facilitation of problem solving within meaningful contexts through curriculum strategies" (p. 19). This, she wrote, requires problem solving to be the focus of not only the work term but also the academic work, that work terms involve problem-solving opportunities of increasing complexity, and a commitment from the employer, the coordinator and the faculty to this orientation. Van Gyn (1994) argued that this approach would lead to the development of critical thinking skills in students and enhance the educational outcomes of a co-op programme. As yet there is no published evidence of the use of this approach, which may stem in part from the difficulty of securing placements with a commitment to problem-solving.

Saltmarsh (1992) also contributed to the debate of the alignment of cooperative education with Deweyanism in his discussion of Dewey's notions of participatory democracy, stimulated by Westbrook's 1991 biography of Dewey. Saltmarsh noted that Dewey wanted people to have access to education through work experience that would allow them to participate to their potential in the workplace and thereby transform it. As Dewey wrote:

> The kind of vocational education in which I am interested is not one which will 'adapt' workers to the existing industrial regime; I am not sufficiently in love with the regime for that. It seems to me that the business of all who would be educational time-servers is to...strive for a kind of vocational education which will first alter the existing industrial system, and ultimately transform it (Dewey, 1915, cited by (Saltmarsh, 1992).

Saltmarsh (1992) therefore noted that if cooperative education is to follow Dewey's transformative ideals then not only would co-op programmes have to integrate classroom and workplace learning, but they would also lead to "education that will provide students with the tools to transform the workplace into an environment that fosters complete self-realization" (p. 9). That is, they will need to be equipped to take a full part in the adult world of work in order to reach their potential to make change. This, Saltmarsh (1992) argued, is at odds with Schneider's (1910) original notion for cooperative education, which lacked any emphasis for social change. He argued that whilst Schneider took a functionalist approach to providing a link between education and work, which would ultimately provide skilled workers to increase production, Dewey was promoting a combination of disciplinary theory and practice that did not necessarily have capitalist development as its goal.

Saltmarsh (1992) further argued that it was precisely Schneider's functionalist approach that proved at odds with the trend towards liberal education in the USA, in the early 1900s, and this pushed cooperative education outside the mainstream of higher education. He asserted that if cooperative education wants to follow Deweyan philosophy, then co-op programmes "must reform their academic curricula for worker 'preparation' in the broadest and deepest sense of the term – the Deweyan meaning" (p. 14). This, he argued, would site cooperative education as interdisciplinary at the university, intertwining classroom and workplace learning. This in turn would legitimize cooperative education as an educative practice and it would become mainstream with respect to the traditions of education.

The arguments made by Saltmarsh (1992) are persuasive in the context of the political and social world. They raise opportunities from a pedagogical viewpoint and possible obstacles from a practical perspective. The co-op work placement provides entry for the student into a world of work where social and political ideals may differ from the university, and are enacted upon in a real setting. This provides the students with the opportunity to gain a greater understanding of the breadth of views held about their discipline.

On the other hand an obstacle to Saltmarsh's (1992) assertions could be the practical difficulty of locating suitable employers who could offer work experience to students who are being educated to bring about social change in their workplaces. In my own experience as a co-op practitioner, on three occasions where students attempted to become involved in social and political issues in the workplace, the employers were not at all receptive. Education of the student as to appropriate ways and means of engaging in transformative actions would need careful planning and may be beyond the scope of many co-op programmes.

In summary Dewey's ideas do hold promise to explain the value of co-op placements. Dewey's promotion of experience as the key to understanding nature and reality, and the importance of communication in sharing that reality, are useful in thinking about how students learn on placement. Dewey saw that context was important for learning and that experience in context can shape the development of knowledge. Importantly, Dewey focussed on the transactional nature of experience, and when combined with the influence of context and the socially mediated nature of learning, his educational philosophy becomes significant in attempts to understand learning through co-op work placements. His emphasis on experience and the social sharing of meaning, particularly through language, point to the importance of the social and cultural influences on learning which are discussed further in Chapter three.

2.4.3.2 Kolb's Learning Cycle

A second proponent of experiential theory has been David Kolb (Kolb, 1984), who has proposed that the transformation of experience leads to learning. He argued that there is a growing interest in experiential learning due to the demands of a rapidly changing social and employment environment, and the demands of students and employers for more relevant and applicable education (Kolb, 1984). He identified three important foundations for experiential theory in the work of John Dewey, Kurt Lewin and Jean Piaget (Kolb, 1984). The ideas of Dewey and Piaget with respect to experience have been discussed earlier. Lewin developed

ideas of organisational training and development that spawned laboratory-training methods. His central notion was that learning occurred when there was "dialectic tension and conflict between immediate, concrete experience and analytic detachment" (Kolb 1984, p. 9). That is, an opportunity to juxtapose experience with theory led to learning.

Kolb's (1984) Experiential Learning view was primarily based on Lewinian, Deweyan and Piagetian ideas and was described as a cycle. Kolb (1984) adopted Lewin's (1964) Experiential Learning Model as a base for his view. Lewin's cycle began with a concrete experience which was then reflected on. This reflection led to abstract conceptualisation of what the experience meant, and this conceptualisation was then tested in new situations. The experience gained from these tests was then reflected on and the cycle began again. This led to an effective goal-directed learning process. Kolb saw Dewey's ideas of learning transforming concrete experiences into purposeful action as similar to Lewin's. To these ideas Kolb (1984) added Piaget's (1950) Stage Theory view that cognition develops from concrete experiences towards an ability to reason in an abstract way, to propose a cycle in which experience and abstraction are interlinked.

Kolb (1984) argued that this model "pursues a framework for examining and strengthening the critical linkages among education, work, and personal development" (p. 4). He believed that it emphasized links between the classroom and the real world, saw the workplace as a learning environment, and engendered the notion of lifelong learning. Kolb advocated viewing learning as a process, not as specified outcomes, and the process view saw learning as continuous and not as an endpoint, as outcomes can be viewed. He supported Jerome Bruner (1966) and Paolo Freire (1974) in their assertions that education is about stimulating inquiry and not about obtaining a body of knowledge.

Kolb's emphasis on the links between the classroom and the real world, led Cates and Jones (1999) to express the belief that Kolb's Experiential Learning Cycle (Kolb, 1984) may be the most relevant learning theory for cooperative education. They argued that each of the four stages of Kolb's learning cycle can be

experienced through a co-op programme, particularly those in which students undertake multiple placements, allowing them to test their new understandings in new situations. Accepting such a view would place a responsibility on co-op practitioners to structure their programmes to allow students to fully exploit each part of the learning cycle.

It is hard to disagree with Cates and Jones' (1999) assessment above and there is little doubt that Experiential Theory offers fertile ground for exploring the learning process that students go through during their co-op degrees. By investigation of their experiences, some understanding may be gained of what the students learn from their work placement experiences.

In summary the experiential learning philosophy appears to offer much to explain learning in cooperative education. It emphasises the link between experience and cognition and the importance of seeing learning as an active process built around successive experiences. If it fails to explain any aspect of learning through work placements, it would be in its lack of emphasis on the role of cultural and historical factors on learning. For example whilst some proponents have included mention of the influence of social factors in experiential learning, they appear to have been viewed as having more of an effect at the individual interactional level and not at the societal level. In other words, there is an acknowledgement of learning through experience by direct social interactions with others, but less emphasis placed on the role that the complete socially-mediated environment including artefacts such as language and technical devices might play in learning. In my experience as a co-op practitioner, students have commented on the differences in their experiences in the social and cultural environments of the university and the workplace, and even between different workplaces. This has indicated that to me that these differences might be important to their learning.

2.5.4 Reflective practice

A part of the assessment process for the BSc(Tech) co-op programme, and other programmes that I aware of, involves the students in reflecting on their learning on their placement. This reflection has been theorised as contributing to learning

from experience (Boud, Keogh, & Walker, 1985; Schon, 1983). Reflection can be viewed as a response to experience in which "people recapture their experience, think about it, mull it over and evaluate it" (Boud et al., 1985, p.19). This process involves problem-finding and problem-solving, judgement-making and action-taking, When this process is actively and consciously pursued, it becomes an educative process. Schon (1983) described reflection as including reflection-on-action, in which the person reflects on a situation after its occurrence, and reflection-in-action, in which the person considers what they are doing while they are doing it.

The importance of employing reflection in the workplace, a context emphasised in cooperative education, has been described (Marsick, 1988; Marsick, 1990) as providing a vehicle for continuous learning and improvement in practice. Schon (1983) asserted that professional knowledge, such as in science and technology workplaces, cannot merely be explained by technical rationality (scientifically rigorous problem solving) as it fails to account for practical competence in divergent situations. He proposed instead reflection-in-action by a professional practitioner, in which the practitioner thinks about their practice as they practice, and hence develops knowledge and understanding of their practice.

Boud, Keogh and Walker (1985) proposed a three-part model for reflection that could lead to learning. In Stage 1 the reflecter goes over the experience again in their mind, in Stage 2 they attend to the feelings during the experience, and in Stage 3 they re-evaluate the experience using four elements. These are association – relating new data to that which is already known; integration – seeking relationships among the data; validation – to determine the authenticity of the ideas and feelings which have resulted; and appropriation – making knowledge one's own. These stages hold some similarity to Piaget's elements of assimilation, accommodation and equilibration.

In a later article Boud and Walker (1998) recognised the impact of the context in which the reflection takes place. They argued "that the social and cultural context in which reflection takes place has a powerful influence over what kinds of reflection it is possible to foster and the ways in which this might be done" (p.

191). The influence of the social and cultural environment on learning is explored more deeply in the following chapter.

The idea of the reflective practitioner as a useful theoretical tool for cooperative education has been discussed (Van Gyn, 1996). As Van Gyn (1996) pointed out, within colleges and universities "the traditional learning process in which those who know (the faculty) present ideas to those who do not (the students) is strongly entrenched" (p. 113). In her view of traditional learning, theory or knowledge was of utmost importance and the link to practice was not explicit, yet what she believed was required in the workplace and life in general was a thinking and reflecting individual.

The notion of reflective practice as espoused by Schon (1983) includes collaboration (social interaction that allows for shared meaning making), dialogue (the use of communication to promote thought), action research (a collaborative problem-solving approach) and analysed apprenticeships (constructive analysis of experiences). Work experience is an effective vehicle for these aspects, whereas traditional academic classrooms are not. Van Gyn (1996) argued that co-op programmes hold the promise to enable the development of reflective practitioners. As she noted it "would require that both the classroom experience and the work placement experience be filled with discussion, debate, research and collaboration and that all partners including faculty, coordinators, students and employers would be willing to fulfil the role of the learner and the learned" (p. 127).

In summary reflective practice is linked to experiential learning in that the individual is actively encouraged to reflect on and in their experience, in order to learn from it. It can be seen as a valuable tool to enable learning from co-op work placements, but one in which some instruction for students as to the means of reflection may be necessary before they undertake work placements.

2.5.5 Multiple Intelligences

In an attempt to understand the learning process and outcomes of co-op students on placement, and how they may differ from those that occur in the academic institution, some educators have examined the theoretical ideas that espouse different views of intelligence and cognitive ability. Their ideas may allow for a view of learning that is broader than the traditional academic learning, and therefore permit a view of how different learning may occur in a work placement to that which occurs in the classroom. This section reviews some of these ideas.

A very traditional view of intelligence posits that it exists as a singular kind of entity within the mind, and that it can be measured precisely (Gardner, 1983). The evolution of measurement techniques have led to the designation of an intelligence quotient, or IQ, that could be found for every individual, and that could be, and has been, used to rank people in order of so-called ability. Critics of this view point out that whilst there may be some correlation between IQ and academic achievement, there is a poor correlation between IQ and performance in other spheres such as the workplace (Gardner, 1983; Wagner & Sternberg, 1985), so that a measure of IQ and academic achievement would be a poor predictor for how a student may perform in a workplace situation. Indeed this paradox has been reported numerous times on an anecdotal basis (Coll, 2002, pers. communication) in which students with modest academic records perform exceptionally well in the workplace and secure a very good career. This evidence suggests the possibility of other types of intelligence, or cognitive abilities, which current classroom teaching and assessment do not highlight, and which may lead to learning by students in their work placements.

Gardner (1983) has explored the existence of multiple intelligences. Although he admits to the difficulty of achieving definition, Gardner (1999) gave his definition of intelligence as "a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture" (p. 33). Gardner saw intelligence as a potential that could be activated, but not seen or counted. His emphasis on these potentials being activated within a cultural context indicates a societal value.

Gardner (1983) developed a theory of multiple intelligences through his examination of cases of brain-damaged individuals, idiot savants, prodigies and other exceptional people who have shown outstanding abilities or inabilities in some domains. His theory suggested that there are a number of different types of intelligences and while he cautioned against over-categorising the domains, he put forward the case for eight as follows:

1. Linguistic Intelligence – that pertaining to the use and understanding of language, both orally and in writing.
2. Musical Intelligence – that pertaining to the use and discernment of pitch, rhythm and timber in music.
3. Logical-Mathematical Intelligence – that pertaining to the use and understanding of logic and mathematics, numbers, patterns and their relationships, and by extension the notion of science.
4. Spatial Intelligence – that pertaining to the perception of spatial factors and visual media, and the use of and understanding of colour, shape, form and space and their relationships.
5. Bodily-kinesthetic Intelligence – that pertaining to the use of one's body for expression or to achieve some goal, including the use of tools in work, and covers attributes such as coordination, dexterity, strength and speed.
6. Intrapersonal Intelligence – that pertaining to self-knowledge, the ability of being aware of oneself, and to act in concert with one's own needs.
7. Interpersonal Intelligence – that pertaining to relationships with others. The ability to interact with and be sensitive to others around you.
8. Naturalistic Intelligence – that pertaining to recognition of connections and patterns within the natural world, and to group and classify items, a sensitivity to the natural world and awareness of your surroundings (Gardner, 1999).

Whilst Gardner (1999) recognised that this list may not be the whole story, he believed it could be used as a guiding principle to help us understand the scope of intelligence. The contribution that Gardner makes is to alert us to the possibility of existence of many forms of intelligence. This has implications for education and our understanding of student learning. As he noted, traditional Western-style

classroom schooling focuses heavily on logical-mathematical intelligence, with some value also placed on linguistic and intrapersonal competence. It needs to be acknowledged that other societies and cultures place emphasis on other forms of intelligence or cognitive ability and these can have implications for teaching and learning (Jegede, 1995; Ogawa, 1995). However, it is beyond the scope of this thesis to discuss these implications.

When viewed from a co-op standpoint, Gardner's (1983; 1999) ideas allow for the expression of a multitude of capabilities within different teaching and learning settings. A student who may struggle in a logical-mathematical environment of the classroom, may blossom when using the bodily-kinesthetic, spatial and interpersonal intelligences in the industrial workplace. The opportunity to undertake work through a co-op programme, in a novel environment distinct from the constraints of the classroom, may permit the use of different intelligences leading to learning and development which is valid and important but which is not considered in the classroom (Cates & Jones, 1999).

Gardner's theory not only provides a framework for recognising the expression of capabilities, but also holds potential for an individual to better understand their own capabilities through cooperative education. Indeed in *The Unschooled Mind* (1991), Gardner developed his ideas into a critique of the U.S. educational system, and concluded that there are serious gaps in the types of learners it produced. He advocated a return to the apprenticeship system as a route to better understanding for the learner. He saw the educational value of apprenticeship as involving "the appropriate application of concepts and principles to questions and problems that are newly posed" (Gardner, 1991, p. 117). This notion has been allied to cooperative education by DeFalco (1995), who argued that being on the job is not sufficient as an outcome for cooperative education and that learning cannot be measured in behaviorist terms (see Section 2.5.1). In this manner the emphasis for learning moves to the transferability of skills, knowledge and personal ability from one situation to another, which has implications for cooperative education and assessment of learning on placement. Goals for learning on placement would need to take into account the differences in the opportunities to exhibit different types of capabilities, and for these to be assessed accordingly.

In terms of assessment, what is very clear from Gardner's writings is that traditional university classroom assessment is not appropriate as a means of determining intelligence in any way other than that in which it is grounded, that is, in logical-mathematical and linguistic abilities. Other intelligences should be examined, if need be, as potential and actual expressions of capability within a setting. Indeed in order to be able to assess an individual's capacity to use one or many intelligences and demonstrate their capabilities, Gardner (1999) argued that "we should observe people in real-life situations where they have to be sensitive to the aspirations and motives of others" (p. 208). A co-op work placement offers that real-life opportunity for assessment of an individual's multiple intelligences.

Some critics of Gardner's ideas on multiple intelligences, such as Robert Sternberg, take issue with his assertion that they are independent entities (Sternberg, 1988). Sternberg agreed that there are multiple aspects to intelligence but he argued that there is "overwhelming experimental evidence for links between them, that there are positive correlations between different ability tests within individuals" (p. 73). Gardner has recently stated that certain of his categorised intelligences may indeed be linked with each other in particular settings but not in others (Gardner, 1999).

Many other psychologists, anthropologists and educators have written about the nature of intelligence or cognitive ability, and two others that are germane to cooperative education are considered here. Daniel Goleman has recently described Emotional Intelligence (Goleman, 1996), which he defined as the ability to be "able to motivate oneself and persist in the face of frustrations; to control impulse and delay gratification; to regulate one's moods and keep distress from swamping the ability to think; to empathise and hope" (p. 34). He, like Gardner, saw emotional intelligence as being independent of, and additional to, academic intelligence, and favoured the Gardner notion of the existence of multiple intelligences. The notion of emotional intelligence has some synergy with Gardner's (1983) interpersonal and intrapersonal intelligences.

Goleman (1996) argued that emotions can disrupt learning and that the development of emotional literacy amongst children is a worthy goal. In a social setting such as a workplace, emotions could play an important part in what and how learning occurs. Goleman's ideas provide a further dimension for exploration of the experiences of co-op students in their workplaces, and importantly, an assessment of their abilities to adapt to, and be successful in, a working career in science and technology.

The other work in this area that is particularly germane to this study are ideas about practical intelligence. Neisser (1976) contrasted academic intelligence with what he described as "intelligent performance in natural settings" as "responding appropriately in terms of one's long-range and short-range goals, given the actual facts of the situation as one discovers them" (p. 137). Wagner and Sternberg (1985) term this 'practically intelligent behaviour', and state that it is often accompanied by emotions and feelings, and involves satisfying motives. As co-op work placements emphasise practical work in natural settings, it is possible that this notion may help in understanding learning processes and outcomes in co-op programmes.

Sternberg (1988) has proposed a triarchic view of intelligence, that which contains components (the mental process involved in thinking), experience (which he views as a spectrum of ability from the encounter of a novel situation to the automatized information processing of well-known situation) and context (in which the intelligence exhibited is influenced by the environment). His theory sees intelligence as mental self-management, or "purposive adaptation to and selection and shaping of real-world environments relevant to one's life" (Sternberg, 1988, p.65). In other words, Sternberg's intelligence could be viewed as conscious cognitive ability that leads to construction of a personal reality that is contextually-bound.

With his colleague Richard Wagner, Sternberg has argued that traditional IQ tests have been shown to have a low correlation with occupational performance (Wagner & Sternberg, 1985). They applied the findings of cognitive psychologists that experts and novices differ "in the amount and organisation of their knowledge

about the task rather than in underlying cognitive abilities" (Sternberg, 1988, p. 212), to investigate intelligence and learning in real-world pursuits. Wagner and Sternberg (1985) concluded that much learning in these settings occurs in the absence of formal instruction, and takes the form of tacit knowledge. They define tacit knowledge as that which is practical, informal, and not usually taught directly: knowledge that is not openly expressed or stated.

Wagner and Sternberg (1985) used quantitative methods to test their theories with co-op students and whilst the study had some apparent deficiencies (see section 2.4.2), there were indications that their measures showed an increase in tacit knowledge (practical intelligence) amongst co-op students after their placements (Williams et al., 1992). As noted by Gardner (1999), the use by Williams et al. (1992) of testing methods based largely on linguistics and logical-mathematics may prove to be too closely allied to academic knowledge testing to give a good indication of practical knowledge.

In summary, this examination of some ideas relating to intelligences and their manifestation as abilities shows some relevance to the practice of cooperative education. In terms of understanding learning, the concept of intelligence may be limited if thought of in the traditional sense of being a stable entity that can be objectively measured by traditional university classroom assessment. This limited view of intelligence is often allied to classroom teaching but appears not to reflect what occurs in work placements. But if the proposition that there exists more than one intelligence, or cognitive ability/potential, is allowed, then a broader understanding of what might lead to learning in both the classroom and the work placement is possible. This holds promise for the future of cooperative education as a vehicle for realising the potential of students' multiple intelligences in the different settings, and for shaping ways of assessing their learning in real-world, practical settings.

2.5.6 Adult learning theories

Another theoretical position that could contribute to theorising about cooperative education is that of adult learning theory. A brief look at adult learning ideas is

merited here as the focus of the study is on young adult students, mostly aged between 18 and 21 years, but also with an increasing number of students older than 21 years. Adults could be characterised as having moved from dependency on others for well-being as children, to assuming responsibility for management of their own lives (Merriam & Caffarella, 1999). Most of the students in co-op programmes at tertiary level are at the point of moving between these two stages of dependency.

Knowles (1980) adopted the term andragogy to account for assumptions about adult learning. Knowles saw these assumptions as not as a dichotomy with pedagogy (assumptions about child learners) but as a spectrum within which learning may occur in any given situation (Knowles, 1980). Knowles characterised andragogy as learners being self-directing, experience-based, motivated internally by a need to know and problem centred. In contrast Knowles explained pedagogy as teacher-driven, subject-centred and motivated by external factors.

In general terms, ideas about adult learning and theories to explain the learning processes are still under development (Merriam & Caffarella, 1999), much in the same vein as cooperative education. Adult educators have focussed on the role of experience as a cornerstone of learning as an adult (Merriam & Caffarella, 1999). The inherent social nature of the adult world contributing to adult learning has been explored through alliances between adult learning and sociocultural ideas (Bonk & Kim, 1998), situated cognition (Merriam & Caffarella, 1999), practical intelligence and tacit knowledge (Torff & Sternberg, 1998), and reflective practice (Merriam & Caffarella, 1999). Each of these ideas is also explored elsewhere in this thesis as allied to the discipline of cooperative education, showing some synergy with the study of adult education.

What may prove of value here, in considering co-op students, is an attempt to examine whether differences exist in the learning conditions of the student between the classroom and the work placement. For example, do students on placement adopt a different (more andragogical?) approach to learning in the workplace to that which they may have been using at university? Much of the

adult learning literature focuses on adults who had completed their formal education earlier and were currently fully employed in the work force. As such this area may have limited value to theorising about the majority of co-op students who enter the programmes directly from the level of secondary schooling, although such students may indeed share some learning characteristics with adults.

2.6 Chapter summary

The development and recognition of what is known as cooperative education has grown in recent years from small beginnings to be an educational strategy adopted at tertiary level in many countries of the world. It has largely been an institutional-based pragmatic exercise in which the goals have been orientated towards gaining students work experience which could allow them to apply the theory learnt in the classroom, and gain work knowledge and skills that would complement their classroom learning. The strategy has proven to be highly successful in operational terms in that large numbers of students have completed successful placements and have got jobs in their fields.

However co-op programmes have often been viewed as less academic than their non-co-op counterparts on the grounds that the work placement component is non-educative. Rebuttal of this view by proponents and practitioners of cooperative education has been handicapped by a lack of research-derived knowledge or understanding amongst the co-op community of the educational outcomes and processes in the work placements. In particular there has been a paucity of research looking to link work placement outcomes and processes to educational theory. Research into this area would help practitioners better understand the pedagogy of the work placement, leading to more appropriate curriculum and assessment, and enhancement of the sometimes-threatened legitimacy of cooperative education as a valuable educational strategy.

It is accepted in this thesis that learning is a cognitive process, and this acceptance has focussed attention on a number of possible theoretical ideas that could help explain the learning outcomes and processes of co-op placements. The previous

sections have shown that ideas from Piaget's developmental learning views, the experiential learning ideas of Kolb and Dewey, the views of multiple/practical intelligences, and adult learning ideas have been theorised to contribute to an explanation of that learning. It has been argued however that as this thesis is concerned with understanding what and how students learn on work placements, and how that learning helps them to make the transition between the university and the workplace, that each of these theoretical perspectives can be critiqued as inadequate in some way in explaining that learning.

This research is interested in examining learning in the context of the work placement. Contexts have social, cultural and historical dimensions, that may therefore have a bearing on learning. The nature of these dimensions may be different in the workplace to those experienced in the classroom. An investigation of these dimensions holds promise to help understand the learning outcomes and processes that a student undergoes on placement, and how the learning that occurs on placement may differ from, and integrate with, the learning in a different sociocultural environment, the university. In the next chapter the attention turns to an examination of sociocultural views of learning and the influence of context, leading to a theoretical position which has guided this inquiry.

Chapter 3 Literature Review

Sociocultural views of learning and the learning context of the study

3.1 Chapter outline

The review of cooperative education in the preceding chapter indicates a need for research into learning in co-op programmes that is underpinned by learning theory. Such research could enhance understanding of cooperative education for curriculum, pedagogical as well as political reasons. As noted in the preceding chapter, learning theories that have previously been examined in an attempt to explain learning in co-op programmes have provided some insights into the nature of the learning process and outcomes for students. However, each of those theoretical ideas appears to attribute insufficient importance to the role of social, cultural and historical dimensions in learning, particularly in the work placement. This chapter reviews ideas related to how learning may occur through social, cultural and historical interactions within a context. Section 3.2 discusses these sociocultural views of learning and their potential for explaining learning outcomes and processes within co-op placements.

The remainder of the chapter examines ideas about learning in two key contexts pertinent to this study. The BSc(Tech) co-op programme positions students alongside science practitioners (scientists, technicians, production staff) for work placements over the course of studying for their qualifications. This situates the students in two very different contexts, that of the educational institution (a university in this study) and that of the workplace. What is of interest here is what and how a student learns in the placement (workplace) context in particular, and how their learning in that context may be combined with their learning in the university classroom context to give them a greater understanding of what it means to practice in science and technology. To background these issues, Section 3.4 looks at workplace learning ideas and 3.5 focuses on ideas about learning in science and technology.

3.2 Sociocultural views of learning

This section reviews recent theoretical perspectives on learning as a social and cultural activity that can be described as sociocultural views of learning. In this thesis social is taken to mean interaction occurring between two or more individuals, situated within the community in which they are found (Lave, 1991; Wertsch, 1991a). This includes active interactions involving direct social verbal and non-verbal contact in conversations or group meetings, or passive interactions involving indirect social contact such as reading company instructions. Culture is taken here to mean the customs, shared values and ways of thinking and doing which typify a particular group or community (Levine & Moreland, 1991). This could involve such characteristics as norms of behaviour at tea breaks or how to operate a scientific instrument. This section then focuses on views about learning as a social and cultural activity.

Whilst the idea that learning can be conceived as a social process is not new, it was subsumed in psychology for many years as the attention fell on the individual (Salomon & Perkins, 1998). There has been a renewed interest in social learning as researchers and theorists seek answers to questions about cognition and learning that may not have been satisfactorily addressed through experimentally-based psychology that had largely been based on the individual (Greeno, 1997; Salomon & Perkins, 1998). Ideas emanating from the fields of sociology and anthropology have encouraged the trend.

Albert Bandura provided one view of social learning (Bandura, 1977, 1997) that sought to explain human cognition and behaviour, and which has previously been allied to cooperative education (Cates & Jones, 1999; Fletcher, 1990). Bandura's (1977, 1997) view was underpinned by the roles that vicarious, symbolic and self-regulatory processes play in learning and other psychological functions. He argued that learning is best seen as a continuous reciprocal interaction between individual cognition, behaviour and the environment. This view allows for learning through modelled behaviours such as through mentors at work, and for the development of self-efficacy. The latter is defined as a person's own perceived capability to carry out tasks, and is related to reinforcement given about their

achievements in particular settings. It has been claimed that the level of self-efficacy can affect learning, and that positive experiences can boost self-efficacy (Bandura, 1997).

Fletcher (1990) examined Bandura's (1977) notion of self-efficacy and allied it with cooperative education. Fletcher (1990) argued that co-op experiences enhance self-efficacy through activities that encourage person-job congruence, through counselling interactions that generate persuasory efficacy information, and through activities that foster the setting and acceptance of challenging goals. Fletcher's (1990) conclusion was that research that could validate the link between programme processes and enhanced self-esteem (Fletcher incorrectly labelled Bandura's self-efficacy ideas as self-esteem) would help establish theory-based guidelines for programme structure and help "legitimize co-op as an educational strategy" (p. 52).

Cates and Jones (1999) also examined Bandura's social learning ideas and found some congruence with his notion of observation of modelled behaviour. They saw the opportunities that co-op students have on placement to learn through vicarious means about what behaviours are appropriate in which settings at work. This view of the 'social' in learning emphasises student learning in a community as based in the individual but influenced through social interactions with other members of the community.

What has recently emerged from the literature is a different understanding of the 'social' contribution to learning, which acknowledges the influences of earlier researchers such as Vygotsky and Piaget, and more recently contributors such as Lave and Wenger, and Rogoff (Salomon & Perkins, 1998). Vygotsky and Piaget saw the individual mind as developing in a socially-mediated environment (Piaget, 1950; Vygotsky, 1978; Wertsch, 1991b), whereas Lave and Wenger came to view learning as occurring in social interactions rather than the individual mind (Lave & Wenger, 1991), and Rogoff saw learning as occurring through participation (Rogoff, 1991, 1995).

In examining these notions of social learning, using an approach based around conditions of learning and learning systems, Salomon and Perkins (1998) proposed six perspectives, four of which are of value to consider in this study:

1. The social mediation of individual learning in which systems such as instruction are used. This is seen to occur most successfully when an expert tutor facilitates active, constructive participation in problem-solving in which the social mediation enables learners to solve problems in a process which transforms their understanding and skill (Rogoff, 1991). Apprenticeships can be viewed within this perspective. Within a co-op work placement this type of social learning could occur when a science technician instructs a student in the use of an instrument.
2. Social mediation as participatory knowledge construction, in which knowledge is "jointly constructed ('appropriated') in the sense that it is neither handed-down ready-made nor constructed by individuals on their own" (Salomon & Perkins, 1998). Knowledge and meaning is constructed in a situated context and distributed amongst the participants (Pea, 1997). Participation is seen as the process and outcome of learning rather than acquisition or conceptual change (Sfard, 1998). For example, in a work placement a scientist works with a student to analyse and make sense of some data that the student has generated.
3. Social mediation by cultural scaffolding using artefacts such as tools and information sources. Tools may both perform a required function and enhance thinking and understanding about operations. Importantly tools such as instruments and language are constituted in the social context in which they are found and shaped by the culture in which they have evolved. In a science research environment scaffolding could occur through access to peer journal articles that provide entry for a placement student to the vocabulary of the research field.
4. The social entity as a learning system in which a group such as a sports team or a business constitutes a collective learning system (sometimes referred to as a community of practice). In a workplace, co-op students may find themselves as part of a team engaged on a project, which creates a collective learning system based around their shared endeavour.

Salomon and Perkins (1998) concluded that there were good grounds for an acceptance of a view of social learning that did not preclude the existence of individual learning. Rather they argued that individual learning may occur in a direct or indirectly social way, and that the 'socialness' of the situation may vary over time. They agreed with Sfard (1998) that individual and social learning should be considered together, as existing in a "reciprocal spiral relationship" (Salomon & Perkins, 1998, p. 18), but that they should retain their own identity, in a dynamic complementary interplay.

In considering the possibility that learning can be a social process, recent perspectives on knowledge construction prove useful. These perspectives, collectively known as constructivism (Duit & Treagust, 1998; Piaget, 1950; Resnick, 1991), assert that people/children/students construct their own personal view of reality, and that learning occurs when individuals fit new knowledge into their existing constructs.

These constructions are affected by the sociocultural dimensions of the setting within which they are formed. As Resnick (1991) notes, constructivism "makes cognition integral to social processes" in which "people jointly construct knowledge under particular conditions of social purpose and interaction" (p. 2). These viewpoints are the basis of social constructivist ideas (Bell & Gilbert, 1996; Driver et al., 1994) in which construction of knowledge is seen to be a social process mediated by interaction, but which also acknowledges the interplay between the social and the personal in learning (Bell & Gilbert, 1996).

If learning is viewed as personal construction of reality mediated by social interactions, then how can learning in the co-op work placement be conceived? To answer this question, a consideration of notions of apprenticeship, community of practice, situated learning, distributed learning and mediated action is useful. These are now discussed in turn.

3.2.1 The notion of apprenticeship

The analogy of apprenticeship has been used as a model to describe learning in co-op placements (Heinemann, 1983) in a process by which scholastic competencies are mingled with workplace endeavour (Gardner, 1991). The notion of an apprentice working alongside an expert practitioner appears helpful to understand how a student might learn the craft (Gamble, 2000) of practice.

While the process of apprenticeship can be viewed simply as involving knowledge and skill acquisition through instruction (Salomon and Perkins' (1998) first perspective above), some theorists have explored the sociocultural dimension to learning through apprenticeship. In particular Brown, Collins and Duguid (1989) have proposed a strategy of cognitive apprenticeship to argue for the importance of culture in learning. They elaborated their argument by encouraging the conception of knowledge as tools, as has Resnick (1987). In this manner an apprentice learns to use tools through participation in a particular community and adoption of its culture. Brown et al. (1989) argued that "to learn to use tools as practitioners use them, a student, like an apprentice, must enter that community and its culture. Thus...learning is ... a process of enculturation" (p. 33). Through this process, learners engage in authentic activities, whose meaning and purpose are socially constructed within the community (Hennessy, 1993). As Brown et al. (1989) pointed out, "cognitive apprenticeship methods try to enculturate students into authentic practices through activity and social interaction in a way similar to that evident...in craft apprenticeship" (p. 37). They believed that "cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop, and use cognitive tools in authentic domain activity" (p. 39). The cognitive apprenticeship notion acknowledges the social mediation of instruction within a community shaped by social and cultural practices. In this way a co-op student working in a science research laboratory may be seen to undergo a cognitive apprenticeship by working alongside a scientist engaged in the authentic (everyday) activities that science researchers practice, where meaning and purpose are socially and culturally constructed.

Research by Farmer, Buckmaster and LeGrand (1992) using cognitive apprenticeship approaches showed that they could be useful in helping professionals to learn in ill-defined, risky and complex situations. A similar study in science secondary school laboratory classes has shown that providing students with an authentic context in which they could study meaningful problems of their own interest greatly enhanced the development of the students' science process skills (Roth & Roychoudhury, 1993). Furthermore, in a study of learning arrangements for mine and plant workers, Billett (1994a) concluded that for learning in the context of the mine and plant to be effective, "it needs to be embedded in the authentic activities and social relations which comprise cultural practice" (p. 128). As he noted, this concept "includes acknowledgement of domain-specific knowledge in complex thinking, the social basis of learning and the role that activity plays in cognition" (p. 112).

This notion of the cognitive apprenticeship is helpful in understanding learning in cooperative education, and other forms of work experience (Roth, 1995). The work placement can be viewed as an apprenticeship in which students undertake activity within a socially and culturally derived context, which could allow them to develop cognitive tools within an authentic community of practice. The concept of the community of practice then becomes important and the following section briefly explores this.

3.2.2 Community of practice

The term, community of practice, has been used by Lave and Wenger in their anthropological work to describe social groups that are focussed on a common outcome, for example, Liberian tailors (Lave & Wenger, 1991). More recently Wenger (1998) has broadened the concept to indicate a group of individuals who actively participate in the social practices of a community, and thereby construct an identity in relation to that community. Although this notion has arisen out of work in the anthropology field and latterly by Wenger in the business arena, it has also been more recently considered within education (Bell & Cowie, 2001; Lemke, 1997).

Lave (1991) identified several critical factors that characterise successful communities of practice: the newcomers are served with comprehensive goals and an holistic view of the enterprise of the community, and are able to engage in the community alongside near peers and "exemplars of mature practice" (p. 72). Lave (1991) viewed school and workplaces as communities of practice, although they may often be informal or even ad hoc. She cautioned though that these settings can be highly constrained and lack the potential for true participation, and therefore legitimate access to ongoing practice. She asserted that when these settings reify knowledge as something to be acquired, there is generation of negative value identity and poorly understood communities of practice. Instead members of a true community of practice share (participate) in those practices which are the "property of a kind of community created over time by the sustained pursuit of a shared enterprise" (Wenger, 1998, p.45).

Gee (2000) agreed, that "in a community of practice people affiliate with each other not primarily in terms of shared culture, gender, or ethnicity, but in terms of a common endeavour and the practices through which this endeavour is carried out" (p. 190). He asserted that knowledge is distributed amongst group members and their technological tools, and new workers can be 'apprenticed' by participating in the practices (physical and cognitive) that define the community. Communities may also form and disband regularly, or be stable over time (Roth, 1998a). In many New Zealand science research organisations that students find placements in, project teams assemble to undertake particular tasks and disassemble when that task is complete, and the members of the team re-assemble into new project teams. Each of these teams could be viewed as a community of practice, or perhaps as a sub-community, which carries many of the attributes of the whole research organisation, but also has its own peculiar attributes such as timelines, jargon and instruments.

By participating in cooperative education, students enter workplaces that could be viewed as community of practices. Understanding student participation in such a community may help to explain the learning that occurs in co-op placements. The placement aims to situate the student alongside a practitioner within an authentic context of practice, and to participate in the shared endeavour of the community.

How learning may be conceived as occurring through such situatedness and participation is now discussed.

3.2.3 Learning as a situated and participatory activity

Lave and Wenger (Lave, 1991; Lave & Wenger, 1991; Wenger, 1998) have argued for learning to be viewed as situated within a community of practice. Lave (1991) defines situated learning as emphasizing "the inherently socially negotiated quality of meaning and the interested, concerned character of the thought and action of persons engaged in activity" and "that learning, thinking, and knowing are relations among people engaged in activity *in, with, and arising from the socially and culturally structured world*" [original emphasis] (p. 67). That is, learning occurs within a social situation, cannot be dissociated from it, and can only be understood within the context in which it occurred. The emphasis on social negotiation of meaning highlights the interactional mode of learning in which participants share knowledge and understanding to reach a joint construction of their activity world, such that learning may be viewed as a social process in a community of practice. This relates to Salomon and Perkins' (1998) second perspective on social learning described in Section 3.2.

Lave (1991) sought evidence for this notion in anthropological work done on craft apprenticeships, which she came to view as legitimate peripheral participation (Lave & Wenger, 1991). Studying Liberian tailors, she found that inductees to the craft found a legitimate position at the edges, the periphery, of the tailor community, at which they were allowed to participate in the most basic activities of the craft. Over time they became involved in more complex activities using skills and knowledge gained from the community. In this manner Lave (1991) examined the process "in which the increasing participation of newcomers in on-going practice shapes their gradual transformation into old-timers" (p. 72).

Therefore learning may occur in a manner in which the individual and their environment are mutually constituting (Rogoff, 1995), and the individual learns through interaction with other members of the community. Rogoff (1995) drew on Vygotsky's (1978) view of the mutuality of the individual and the sociocultural

environment, and Dewey's (1916) emphasis on social effects on learning, in developing a notion of learning through participation. As Dewey noted "the social environment...is truly educative in its effects in the degree in which an individual shares or participates in some conjoint activity" (Dewey, 1916, p. 26).

Rogoff (1995) assembled these ideas into a view that cognitive processes such as learning could be explored in three planes that correspond to the personal, interpersonal and community dimensions. In this view Rogoff agreed with Salomon and Perkins (1998) and Sfard (1998) that both individual and social factors are important in learning. Rogoff (1995) saw the three dimensions "as inseparable, mutually constituting planes comprising activities that can become the focus of analysis at different times, but with the others necessarily remaining in the background of the analysis" (p.139). In other words although the individual may appropriate knowledge or change behaviour as an individual, that change is influenced through participation in social, cultural and historical activity (Cowie, 2000).

Rogoff (1995) defined processes that correspond to the planes of analysis as apprenticeship (community), guided participation (interpersonal) and participatory appropriation (personal) and explicated these processes through a study of Girl Scouts in the USA participating in the annual cookie-selling fundraising drive. Rogoff and her team viewed apprenticeship not in the traditional master-apprentice sense but in a wider community frame that includes the institutional structure and cultural technologies. Apprenticeship was seen to be "involving active individuals participating with others in culturally organized activity that has as part of its purpose the development of mature participation in the activity by the less experienced people" (Rogoff, 1995, p. 142). In their research on the Girl Scouts, Rogoff's team analysed the institutional structures of the cookie drive, the roles played within the community and the process of selling. In co-op placements this plane of analysis would involve investigating the influence that factors such as workplace history and structure, philosophy and procedures may have on what a student could learn.

Guided participation was conceived as "the processes and systems of involvement between people as they communicate and coordinate efforts while participating in culturally valued activity" (Rogoff, 1995, p. 142). The guided participation may be tacit or explicit, direct or indirect, and involve personal instruction and indirect involvement with persons or artefacts of the community. In the Girl Scout example, analysis of the arrangements between people was carried out, including how the girls worked together, how they were trained, and how they were supported by the Scouts' partners, parents, and tools of the culture. In co-op work placements this plane of analysis would focus on learning through social interaction (e.g., training, group meetings) and cultural artefacts (e.g., instruments, journal articles) within the community.

Participatory appropriation was viewed as individuals changing "through their involvement in activity, in the process becoming prepared for subsequent involvement in related activities" (Rogoff, 1995, p. 142). By participating in activities, people contribute and learn in a process in which individuals and their social partners "are interdependent, their roles are active and dynamically changing, and the specific processes by which they communicate and share in decision-making are the substance of cognitive development" (Rogoff, 1995, p. 151). Rogoff was at pains to argue that appropriation is not internalisation leading to transformation, rather the process of appropriation is the transformation, and that individuals participating do not merely internalise what they participate in, but actually transform through the participation. Sfard (1998) has questioned the lack of clarity over subject matter when participation as a way of learning is considered, arguing that it makes discussions about transfer of knowledge problematic, and that the conception of subject matter becomes confused in a community of practice when the matter for practice is ill-defined. In this way Sfard indicates the importance of examining learning in co-op programmes through participation *and* acquisition of knowledge. Rogoff (1995) would argue that the subject matter is a matter of shared meaning between participants that evolves through ongoing interaction. The view taken here is that a notion of learning through participatory appropriation is fruitful, but that there exists a body of knowledge which is both obtainable and evolving within interactions within the community of practice.

To return to Rogoff's (1995) Girl Scout example, participatory appropriation was seen as occurring as the Scouts assumed greater responsibility for tasks and began to take short-cuts from the instructions as their understanding of the process developed. In co-op work placements this plane of analysis would investigate student's developing understandings of their work and workplaces, and how their roles and responsibilities might change over the course of their placements. Following students' development over time would become important.

The notion of learning through situated activity and participation is one contribution to sociocultural views of learning. Other contributions come from notions of distributed cognition and mediated action, which are now discussed in turn.

3.2.4 Distributed cognition

A fourth view of learning that underpins sociocultural views of learning is that cognition (e.g. learning) is distributed across a community of practice (Bell & Cowie, 2001; Salomon, 1997b). This view of learning has been informed by theorising about the use of technology in learning (Bell & Cowie, 2001), and considers the role of cultural tools and artefacts in cognition.

The notion of distributed cognition suggests that learning is seen to involve more than just than the person, but the person-plus (Perkins, 1997), being the person plus the surround. In this way cognition (and learning) is seen to be located outside individuals' heads, and composed jointly between an individual and peers, teachers, or through the use of culturally provided tools (Salomon, 1997a). Therefore distributed cognition includes "the surround - the immediate physical and social resources outside the person – participates in cognition, not just as a source of input and a receiver of output, but as a vehicle of thought" and also includes "the residue left by thinking – what is learned" which is situated both in the mind of learner and in the "arrangement of the surround" (Perkins, 1997). A community of practice, such as a workplace, can then be conceived of as having learning distributed across its people and artefacts in a social world of activity

within a cultural medium (Cole & Engestrom, 1997). The distribution of cognition and learning across a community is seen as being stretched over, rather than divided up amongst participants (Salomon, 1997a). Futhermore, "the product of the intellectual partnership that results from the distribution of cognitions across individuals or between individuals and cultural artefacts is a joint one; it cannot be attributed solely to one or another partner" (Salomon, 1997a).

The opportunity that a student may get to learn from the distributed knowledge and understanding within a co-op placement may be subject to their exposure to people and artefacts that afford learning (Pea, 1997). A student may gain the chance to use the expensive analytical instrumentation in a chemistry laboratory and hence be afforded the opportunity to learn what it is for, its place in the community and the relationships it might constitute. What of the student in another workplace setting who is denied access to the latest piece of software? Additionally Salomon (1997a) cautions that not all cognitions "are distributed *all the time*, by *all individuals* regardless of situation, purpose, proclivity, or affordance" [original emphasis](p. 113). As such there may be learning that students could not achieve in their co-op placements, because of their situation, affordance, or simply because it cannot be distributed (Perkins, 1997; Salomon, 1997a).

Nevertheless, distributed cognition remains a useful way to conceive of learning, as a social and cultural activity, in co-op placements. It provides a view of a co-op student becoming enculturated into a new community of practice through their participation in socioculturally-derived activity that allows access to the knowledge and understandings that are distributed across that community. Following this reasoning, research into co-op learning would need to investigate what and how a student learns through their engagement with artefacts in their workplace and their access to the distributory processes that constitute the joint construction of cognition in their workplace community.

3.2.5 Social mediation of action

A fifth view of learning that contributes to sociocultural views of learning is that human action is mediated by tools and signs (Bell & Cowie, 2001; Vygotsky, 1978; Wertsch, 1991b). This view draws on the work of Vygotsky (1978) and mediated action is seen to mean that human action such as learning is effected by tools and signs, which are themselves situated in the social and cultural environment in which they exist (Wertsch, 1991b). This relates to Salomon and Perkins' (1998) third perspective on social learning described above, in which they delineate the process of cultural scaffolding through the use of tools and signs.

Wertsch (1991a) identified three themes from Vygotsky's writings: his use of a genetic analysis that argued for the co-mingling of the natural and the cultural in an individual's development; the social origins of mental functioning in the individual; and that higher mental functioning is mediated by tools and signs. Wertsch (1991a) asserted that it is the third of these ideas, mediation, which distinguishes Vygotsky's beliefs from others such as Piaget (who worked extensively on development) and Mead (who worked on social origins of individual psychological functions).

Wertsch (1991a) separated the mediational means into technical tools (such as instruments and computers) and psychological tools (such as language and counting systems). Two key ideas arise from consideration of the influence of mediational means. Firstly they are used in social interaction, particularly in the case of language. Secondly they are "products of sociocultural evolution, and are inherently situated in sociocultural context" (Wertsch, 1991a, p. 91). This, Wertsch (1991a) argued, locates mental functioning together with a mediational means. Wertsch (1991a, 1991b) combined Vygotsky's views with those of Bakhtin's interest in 'voice' to assert that one way of investigating sociocultural approaches to how the mind works is through social language. As language is used in the workplace, this approach would appear to hold promise in understanding how students learn in their co-op work placements. As well as this

all students in co-op placements are likely to be required to use some form of instrument or other tool that could affect their learning.

The notion that learning occurs through mediated action in social situations therefore has relevance to this study. In order to investigate the role of mediated action in students' learning in co-op placements, research would need to focus on the roles of talk and language in that learning, and how other mediational means such as instruments and computers may also play a role.

3.3 The usefulness of sociocultural views of learning to cooperative education

Sociocultural views of learning have drawn inspiration from a number of fields of study to provide perspectives that see mental processes as related to their social, cultural and historical settings (Wertsch, del Rio, & Alvarez, 1995). Co-op qualifications position students within two distinct sociocultural settings, the educational institution (e.g. university) and the work placement.

The sociocultural setting of the educational institution, in particular a university, is characterised by the transfer of domain-specific knowledge and ways of thinking, and attainment of qualifications. The university situates the student within a context in which learning is socially-mediated through lectures and practical classes as well as through artefacts such as books and computers. The student comes to participate in a domain-bounded community of practice whose shared endeavour is to advance knowledge and understanding within that domain. However at the undergraduate level distribution of knowledge is often uni-directional, from the expert source to the student, and the student could not be readily seen as actively participating in the joint construction of new public knowledge. Action is less emphasised in this setting and learning is assessed in terms of individual knowledge and understanding that does not acknowledge the sociocultural setting in which learning occurs. The student operates within a sociocultural framework of class timetables, assignments and exams and peer social interactions.

In contrast the sociocultural setting of the work placement is characterised by the highly situated activity of participation that emphasises ways of doing, and in which the student co-participates in the joint construction of new knowledge. The co-op placement situates the student in a context in which knowledge and practice are equally important. From a sociocultural viewpoint, learning may be seen as occurring through participation in a community of practice (Anderson, Reder, & Simon, 1996; Greeno, 1997). Learning is mediated through the use of tools and language and is distributed across the community in all directions. Action is seen as important and learning is assessed as increasing participation within the community. The student operates within a sociocultural framework of shared endeavour shaped by productivity, the working hours and the culture of the workplace.

Co-op work placements introduce the student to an authentic work context. This context is one in which the student works alongside practitioners who are seeking personal and organisational (including scientific and technological in this study) outcomes in line with the career interests of the student. The immersion of the student-learner in such an environment exposes them to all those elements of practice which cannot be easily taught explicitly and "are tacit and embodied in the actions of experienced practitioners" (Roth, 1998b, p.170). Working in an authentic context allows reflection-in-action (Schon, 1987) to occur, permitting students to develop a 'feel' for the parts of practice that are not implicitly taught (Bourdieu, 1992). This 'practice' view of cognition encourages consideration of modes of learning in which students can gain both explicit and implicit knowledge (Roth, 1998a), and cooperative education with an emphasis on each mode of learning goes some way to achieving that.

Being a part of a community of practice means the students are encouraged to alter their knowledge structures and their actions as they engage in activity. As already noted, this is a different style of learning to that they have been exposed to at university, in which the mode of teaching is often transmissive and abstract. Roth (1998b) has argued that in traditional science schooling practices, students do learn in the classroom, but the knowledge they gain "has little to do with everyday scientific practices" (p. 174). It is likely that the same could be said of

university classrooms (Edelson, 1998). This would indicate that students in the science and technology co-op programme being studied here may experience some conceptual change in their thinking about what it means to practice science between their university and workplace experiences.

Seen from a sociocultural perspective, co-op programmes offer learning opportunities in two distinct sociocultural settings. Each setting permits different learning opportunities, and students are likely to conceive of their learning in each setting in a different way. Students in co-op programmes are generally exposed to learning in a more individual cognitive attainment setting through their university studies, in which knowledge is thought to be acquired in a manner that largely ignores the sociocultural setting in which learning occurs. A question then arises as to what and how these same students may learn when placed in the context of the workplace, where the emphasis may be less on cognitive attainment and more on situated activity and participation. The next section examines what research and theorising has been published about learning in the context of the workplace.

3.4 Learning context: The workplace

Over the past 20 years there has been an increasing amount of research carried out with a goal of better understanding the workplace as a social, political and educative environment. This has led to an increasing recognition of learning in the workplace (Davies, 1998), both at the individual and the organisational level (Karakowsky & McBey, 1999). It has also led, in a way that promises to inform research into cooperative education, to theorising about workplace learning from the perspective of fields such as sociology, cognitive psychology, policy studies, management theory, adult education, economics, learning theory and industrial psychology (Hager, 1999).

The workplace plays a key role in any co-op programme, and it is the period that the student spends in the workplace that sets such a programme apart from non-co-op programmes. Not only that but it has long been realised that most adults spend a considerable period of their lives in the workplace, and increasingly they are expected and encouraged to learn in the workplace, making this environment

worthy of study. Compounding this worthiness is the recognition that the conception of the workplace is changing, as is the nature of work (Wirth, 1991). The separation of work and learning ('work is for working and not learning') is dissolving (Boud & Garrick, 1999), and a new field of workplace learning is emerging, in which "learning tasks are influenced by the nature of work, and, in turn, work is influenced by the nature of the learning that occurs" (Boud & Solomon, 2000).

This emergence of interest in workplace learning has reached the governmental policy stage in Australia (Cornford & Beven, 1999) where politicians have perceived learning in the workplace as a "means of maintaining or enhancing knowledge and skill levels for national prosperity and economic power" (p. 27). Other governments have also shown increasing interest in the value of learning opportunities in the workplace (Dearing, 1997; Labour Party, 1999) but in these instances support has not reached the level of policy.

Work involves increasing automation, requires greater levels of skills, flexibility and adaptability on the part of the worker, and success may no longer reside in the mass production of commodities (Gee, 2000). Some of the major countries of the world, for example the USA, have addressed this trend by calling for higher academic achievement to provide a more educated workforce, a move that Levin (1994) believes may be misguided on the basis of the lack of evidence correlating improved test scores and higher productivity. Both Gee and Levin recognise a need for an education that provides broad-based perspectives for human development and productive work, and where students "would come to understand how to work collaboratively on projects in communities of practice wherein knowledge is distributed across people, tools and technologies" (Gee, 2000, p. 193). This view is in line with sociocultural views of learning, which acknowledge the social sharing of knowledge, and that learning is spread over a community of practice.

The conundrum in education is that although "the popular wisdom among professionals is that the knowledge they acquire from practice is far more useful than what they acquire from more formal types of education" (Cervero, 1992, p.

91), society has given greater legitimacy in this century to knowledge that is formal, abstract and general, as gained through formal, institutional learning. Cervero argued, in the continuing education of professionals in the workplace, for a return of focus to practical knowledge, which is situated in time and context and oriented toward action. He believes that the goal of professional practice is 'wise action' which "means making the best judgement in a specific context and for a specified set of ethical beliefs" (Cervero, 1992, p. 92). This view situates action in context and concurs with a sociocultural approach to cognition. It is likely that Cervero is undervaluing the knowledge acquired by a science and technology student at university, as some evidence of knowledge (such as courses passed) is often a pre-requisite for an employer to take on such a student. It would be of interest to determine how co-op students felt about the utility of their placement-derived knowledge compared to their university-derived knowledge.

From a similar standpoint to Cervero (1992), the adult learning field, comes the theory of andragogy – adult education, in contrast to pedagogy. As noted earlier (Section 2.4.5) the discipline of cooperative education could be thought of as at the junction of the pedagogical and andragogical models. The students are still immersed in the pedagogy of the university but given opportunities to experience an andragogy-type situation in the workplace. It is possible that this change in approach to teaching between the workplace and the university may cause some difficulties for students. A co-op programme holds potential for a study of the difference between, and integration of, the two modes of learning in the different sociocultural settings, and whether these difficulties are experienced.

It has been argued (Resnick, 1987) that theorising of school learning differs from other learning by being based on individual cognition rather than shared cognition, by using pure mentation rather than tool manipulation, by using symbol manipulation rather than contextualised reasoning, and by adopting generalized learning rather than situation-specific competencies. That is, workplace learning may require a different learning orientation to that which students have been exposed to at school. It is likely that in these settings, the workplace and the classroom, that Resnick's (1987) distinctions are not absolute, but they do provide a point of reference to consider in the student's experiences in each setting.

Consideration of this potential difference in learning between the settings in cooperative education raises a question about the approach taken to the placement by academic teaching staff. Depending on the particular co-op programme, these faculty may be involved in supervising and assessing the student's placement, and may be involved in placing the students as well. In her study of academic staff involved in co-op programmes Martin (1998) found that those staff who conceive of learning in the workplace as a simple acquisition of skills, as they may conceive equally of university learning, tend to leave work placement students dissatisfied with their experiences. Those, however, who foster engagement of the student in the issues at work in a more andragogical-type model such as student-motivated engagement in problem-solving see evidence of greater student development.

But what about the workplace as a setting for learning? One researcher who has explored this issue recently is Stephen Billett (Billett, 1993, 1994a, 1994b, 1998, 1999, 2000). In his examination of workplace learning, he argued for guided apprenticeship learning, situated on the job, and outlined approaches to learning at work including engagement in authentic activities, movement from peripheral tasks to more central ones, and access to expertise (Billett, 1994b). The apprenticeship model sees the novice (at the periphery) working alongside the expert or master (at the centre) to gain skills and knowledge (through authentic activities) with the goal of accomplishing tasks, such that the apprentice accumulates learning to the point of mastery (Berryman, 1993). Traditionally it has been thought from this model that the apprentice learns from what is visible, that is, the master's work, and the model was seen to satisfactorily explain the learning of manual practices. However a broadening of this apprenticeship view, brought about by a consideration of apprenticeship to practices such as management and law, sees a situation in which "cognitive skills complement embodied knowledge in importance" (Berryman, 1993, p. 391). This relates to the concept of a cognitive apprenticeship (Brown et al., 1989) as discussed earlier (see Section 3.2.1), which explains the enculturation of an apprentice into a community of practice through acquisition and use of cognitive tools in authentic domain activity, and may be applied equally to manual as to professional work.

Billett (1999) further argued that workplaces act as learning sites by exposing individuals to problem-solving opportunities of a routine and non-routine nature. He asserted that from the activities that the worker engages in every day, they construct knowledge. The degree to which knowledge may be constructed is based on the opportunities provided, and on the received level of direct guidance by experts and indirect guidance from the setting. Therefore "learning is seen as a process of appropriating socio-historically derived knowledge" (Billett, 1998, p.51). In this way individuals construct knowledge based on their own (guided) experiences which are embedded in a sociocultural context.

However, merely being in a workplace does not necessarily lead to learning. As Moore (1986) found from his study of interns in a furniture shop and the animal protection league, learning required engaging with that workplace, participating in it and assessing the way it accommodated that participation, ideally even reflecting on the experience. Billett (1999) argued that for programmes such as cooperative education to operate effectively, they needed to consider the strengths of workplaces as learning sites, but also their potential limitations. He included in the latter such concerns as student access to authentic activities, uncooperative and inaccessible experts and intensely conceptual knowledge. Therefore a workplace will contribute to learning depending on its affordance of access to work activities and guidance (Billett, 2000). In other words, learning in the workplace through co-op placements could become stifled when the student is not permitted to engage in authentic activities, is given limited expert guidance and left to struggle with complex workplace knowledge. In co-op placements this caution would place an onus on the placement facilitators (coordinators and supervisors) to ensure an appropriate level of engagement and supervision to enhance a student's learning opportunities.

In addition Cornford (2000) cautions that the tension between production and learning in the workplace could easily lead to the latter suffering. In a manufacturing environment such as a dairy factory or timber mill, where deadlines and orders must be filled, expedience may take precedence to concern for the learner. As a consequence the student on placement in these areas may be

assigned a routine task which requires little training to gain a steady output, and confinement to such a task with little interaction with a supervisor may afford little opportunity for learning beyond a narrow sphere. In contrast, in a research environment in which productivity is conceived of differently, a student may gain greater learning opportunities. An investigation into the consequences of this production/learning tension for learning in co-op placements would be important.

A further concern for learning in the workplace is the question of power relationships. When considering the apprenticeship analogy, the power in the workplace resides in the expert, as it does in the teacher in the classroom. But whereas the classroom teacher generally has a defined and public curriculum to deliver, the workplace expert can deliver his/her own curriculum and be the gatekeeper of knowledge. This can sometimes lead to a less than ideal learning situation should the workplace expert choose to withhold information and knowledge (Gamble, 2000).

A related problem has been reported in the teaching literature about the power relationship at work (McGee, 1996; Turnbull, 1997). McGee (1996) reported on research into student teachers' experiences of their practicums and found that the students felt constrained to conform with their associate teacher's (workplace supervisor) practice as they knew that this person's assessment of them could impact on their ability to get a job. Whilst it could be argued that the students were learning to conform, it raises concerns about the emancipatory and developmental nature of this workplace. It suggests a reproductive element in the way of practicing, and from an educational standpoint, leads to concerns for objective assessment of ability. These power issues would be important to consider in any research into learning in co-op placements.

Despite these concerns a number of studies have provided some evidence of learning in the workplace. This research has indicated that working knowledge is complex, and depends on and regulates forms of action (Scribner, 1985); that paramedics at work learn through non-routine situations, and through their relationships with their working partners (Lovin, 1992); that subordinates learnt work values in organisations in many cases from their superiors' modelling of

them (Weiss, 1978); and that women entrepreneurs develop a process of 'knowing on the fly' in which they learnt as the situation developed (Fenwick, 2000).

It is clear that learning at work, much like learning in any sphere, is complex and no single theoretical position may be able to explain the process. An interdisciplinary approach to its study is likely to bear most fruit (Garrick, 1999). One perspective of 'dominant discourses' about learning at work is provided by Garrick (1999). He listed four discourses: human capital theory that examines the productive capabilities of human beings; experience-based learning in which workers learn from experience; cognition and expertise which focusses on the workings of the mind, knowledge construction and the development of expertise; and the development of capabilities and competence. Garrick concluded that these discourses do not exclude one another and that a clearer understanding of workplace learning may emerge from a synthesis of many ideas. Further research is needed to add to this list by considering how sociocultural views of learning can contribute to an understanding of learning in the workplace through co-op placements.

To conclude, an examination of the literature indicates that learning does occur at work, and that the learning is influenced by the social, cultural and historical facets of the setting of the workplace. Learning at work can be conceived of as apprenticeship in which both a student's manual and cognitive faculties may be called upon. It may be facilitated by guided participation in authentic activities embedded in a sociocultural context. It may be influenced by issues of access to activities and supervision, focus on learning, and power relationships. Research into learning at work through co-op placements could be usefully conducted using sociocultural views of learning.

Any investigation of learning in co-op placements would need to consider the ideas about learning in the discipline in which the students are studying. The discipline is an integral part of the sociocultural settings within the workplace and the university. It would be of value to understand how learning of discipline knowledge and skills in each setting complements each other. In this inquiry the students are studying science and technology programmes, and are placed into

science and technology workplaces. As such an examination of ideas about learning in science and technology is important as a contextual background to this study, and the following section provides that focus.

3.5 Learning context: Science and technology

This section provides an overview of ideas about learning in science and technology. These subject areas form the focus of study for the students in this inquiry, so are a relevant part of the context for their learning, both at the university and in their science and technology workplaces. One of the goals of a co-op placement is to provide students with opportunities to understand how their studies of knowledge and practice in the university can be utilised in the workplace, and to learn about what it means to engage in authentic context practice in their discipline outside of the university classroom. As such an examination of how students learn in science and technology contributes to an understanding of what and how students may learn about these subjects in co-op placements.

Ideas about learning in science have generally followed the pattern of educational learning theory, since the inclusion of science as a curriculum subject came about in the early 19th century (Matthews, 1998). In contrast technology as a recognised curriculum subject is a more recent phenomenon, emerging in New Zealand in the early 1980's (Burns, 1992), and as a consequence learning theory ideas in technology are confined to the trends in the wider education fields over this more recent period. Learning in science and in technology are discussed separately, although it is recognised that students in this study may have been exposed to knowledge and practice in these two areas, in both an isolated and an interconnected way at various times.

3.5.1 Learning in science

It is pertinent at this point to first raise the question of the nature of science. It is one that has been debated for many years (Matthews, 1998) and while a full review of that debate is beyond the scope of this thesis, it is noteworthy that recent

views about the nature of science have emphasised the inherently social and cultural construction of scientific knowledge (Driver, 1995; Hennessy, 1993; Knorr-Cetina, 1981; Kuhn, 1970; Lave & Wenger, 1991; Lemke, 1993; Roth, 1995).

Kuhn (1970) was one of the first to argue for the social construction of science. Far from seeing science as simply an empirically-derived body of knowledge obtained by individuals using objective means, Kuhn argued for a view of science as a socially constructed and managed process. He distinguished between 'normal science' in which scientists practice within existing theoretical frameworks, and science in which anomalous data leads to alternative theory and his so-called 'scientific revolution' (Kuhn, 1970). This revolution was seen to come about as scientists undertake a social negotiation of the veracity of different theoretical positions. This social construction view has been fostered by the work of sociologists and anthropologists who have studied the practice and talk of scientists (Latour & Woolgar, 1979; Lynch, 1985). This view is further explicated by notions of socially-mediated knowledge construction within scientific and technical communities of practice (Knorr-Cetina, 1981; Lave & Wenger, 1991), in which social interactions within the community lead to joint construction of new knowledge. Additionally the social influence on the nature of science is conceived of in two further ways: firstly, social factors determine what science areas are supported and funded (e.g., the role of funding agencies) and hence pursued; secondly, the process of allowing scientific contributions to knowledge is through socially-based peer review, which the science community controls (Driver, Leach, Millar, & Scott, 1996).

Science can be viewed as an accumulated body of knowledge about natural phenomena, and the process of adding to that body (Good, Herron, Lawson, & Renner, 1985; Kerlinger, 1986), with the aim of explaining natural phenomena and developing theory. Driver et al. (1996) also emphasised that the purpose of scientific work is to explain natural phenomena; that the nature of scientific knowledge and inquiry is the subject of debate but that it involves collection of data and construction and modification of theory; and that social factors are

important in establishing scientific knowledge. This view acknowledges the importance of the sociocultural context of the scientific community of practice.

So what about learning in science? As noted earlier, the 20th century witnessed a transition in learning theory prominence between the behaviourist notions of the first half of the century to the cognitive ideas of the latter half. This change in learning theory adherence was equally evident in science education. By the late 1960s attention was turning to Piaget's ideas of intellectual development (Duit & Treagust, 1998). His stage theory of development in which cognitive changes occur according to age and maturation, although latterly criticised (Duit & Treagust, 1998) as ignoring the context for thinking and learning, led to notions about how children construct knowledge from their experiences. As discussed in Section 2.5.2, the ideas of assimilation, accommodation and equilibration were key to his ideas. These notions are viewed as the forerunners of the next theoretical approach to influence science education, that of constructivism (Driver & Easley, 1978; Duit & Treagust, 1998; Fensham, Gunstone, & White, 1994; Glasersfeld, 1998).

Constructivism has dominated the field of science education through the 1980s and 1990s (Duit & Treagust, 1998). Initially the focus was on students' individual/personal construction of meaning (Bell & Gilbert, 1996; Duit & Treagust, 1998) emerging from work on alternative conceptions and what was called children's science (Bell, 1993; Osborne & Freyberg, 1985; Osborne & Wittrock, 1985). In the generative learning model (Osborne & Wittrock, 1985), proposed to account for personal construction of meaning, the learner was seen to select sensory input on the basis of their existing ideas; attend to new sensory inputs and make links with memory; and then to test constructed meanings against existing and novel frameworks. The construction of meaning was the responsibility of the individual.

This focus on personal knowledge construction positioned the science learner at the centre of the learning process. However, the personal view of constructivism was criticised as not considering the social and historical dimensions to knowing (O'Loughlin, 1992). In latter years the constructivist debate extended to whether

construction is an individual or social process (see also Section 3.2), with most commentators acknowledging that learning may contain aspects of both (Bell & Gilbert, 1996; Duit & Treagust, 1998; Fosnot, 1993; Hennessy, 1993; Salomon & Perkins, 1998; Sfard, 1998). This view is that knowledge construction is both personal and socially shared and that an interchange between these two is involved in learning.

This shift to acknowledging the social contribution to learning in science led to notions of social constructivism (Bell & Gilbert, 1996; Driver et al., 1994). Bell and Gilbert (1996) proposed this notion as acknowledging that "personal construction of knowledge is socially mediated", and that "social construction of knowledge is personally mediated" (p. 50). This made the social context an integral part of the activity of learning, "which considered both the development of the individual's construction of meaning towards the socially agreed to knowledge and the reconstruction and transformation of the culture and social knowledge itself" (Bell & Cowie, 2001, p.115).

There have been criticisms of constructivism as a basis for looking at learning in science. These have included its failure to address the actual learning of a body of scientific knowledge (Solomon, 1994); its lack of recognition of cultural influences (Matthews, 1994; O'Loughlin, 1992); and that constructivism does not explain the way scientists work (Bereiter, 1994; Osborne, 1996). On this final point, Driver et al.(1994) argued that for primary and secondary school students, a distinction could be made between learning public science knowledge and creating new knowledge through scientific inquiry, and that young students were not engaged in schooling in the latter. However, for tertiary students who might enter a science research environment for the first time in a co-op placement, learning may involve both public and new knowledge, depending on the student's access to activities that may afford generation of new knowledge.

In considering these criticisms, constructivism remains a fruitful way of thinking about learning in science when combined with a sociocultural perspective (Bereiter, 1994; Cobb, 1994). Cobb (1994) argued "that the sociocultural perspective informs theories of the conditions for the possibility of learning,

whereas theories developed from the constructivist perspective focus on what students learn and the processes by which they do so" (p. 13). That is, learning involves both cognitive self-construction and enculturation into a community of practice bounded by a context, but also potentially between and across communities to account for transfer in the 'polycontextuality of learning' (Engestrom & Cole, 1997) .

The influence of context on learning science has increasingly permeated the education and the science education literature in the past 20 years (Bell & Cowie, 2001; Cosgrove & Osborne, 1985). Constructivism emphasises the importance of context in learning, in which new understandings are constructed when links are made between ideas located in different contexts (Bell, 1983, 1993; Carr et al., 1994; Osborne & Wittrock, 1985). Acknowledgement of the role of context fits with ideas of situated cognition (Brown et al., 1989) in which learning and cognition "are fundamentally situated" (p. 32), and creates a connection between school type activities and professional science activities (Lemke, 1997). This posits that learning requires a "change from one sociocultural context, usually the everyday context, to a new, science context, or in other words, changes from the practice of one culture to another" (Duit & Treagust, 1998, p. 18). These ideas fit with the conception of a cognitive apprenticeship (Brown et al., 1989; Hennessy, 1993) in which the expert (teacher) guides the novice (student) into the new culture.

Science can be conceived of as a culture in which its practitioners "share a well-defined system of meaning and symbols in terms of which social interaction takes place" (Cobern & Aikenhead, 1998, p. 41). Scientists then constitute a community of practitioners whose practice is socially mediated through the tools and signs, including language and talk (Lemke, 1993), that occur in that community. It is important to note that the same science may not be practiced in all communities, and indeed science as is formally practised in New Zealand is sometimes called 'Western science' to distinguish it from science as it is claimed to be practised in many indigeneous cultures, for example Maori science in New Zealand (McKinley, McPherson Waiti, & Bell, 1992) or African science (Jegede, 1995). However, in all cultures it is likely that the 'subculture' of science is at odds with

the students' everyday world culture (Cobern & Aikenhead, 1998). The learning of science has been described as a cultural border crossing from the subculture of everyday life into the subculture of science (Aikenhead, 1996). It would seem to be valuable to examine the nature of the border crossing that occurs in a science and technology work placement, and whether the experience opens or closes the barrier to that crossing.

In a co-op programme the students attempt to cross the border between science practice in the university and that in the workplace. Edelson (1998) described the characteristics of science practice as being attitudes, tools and techniques, and social interaction. He characterised the attitudes of scientific practice as uncertainty and commitment, and argued that for learning to be successful students should be allowed to develop and employ these attitudes within social interactions that echo those of a scientific community. The part of the university curriculum and pedagogy which attempts to expose students to science practice is the laboratory setting, which as Edelson (1998) pointed out involves experimentation that "usually removes any uncertainty, does little to obtain student commitment, and places minimal importance on social interaction" (p. 320). It is possible that co-op students may encounter a different science practice in their work placements, which may be seen by the students as authentic science environments.

In authentic practice settings newcomers enter the community to co-participate with old-timers (Brown et al., 1989). Over time they move from the periphery towards the core of participation as they gradually learn about practice (Lave & Wenger, 1991; Roth, 1998b). This is an interaction in which they not only change themselves but also contribute to change in the practice and its community (Roth, 1998a) through their participation.

In describing authentic environments (Roth, 1998a) has done most of his work with school science students. He asserted that in order to generate an authentic learning context in school, it is not so much about duplicating exactly the tasks that might be undertaken in a community of practice. Rather it is about providing learning environments that encourage development of the language, reflective

activity and social interactions that these communities practice. In this way Roth (1998a) focuses on skills and understandings that might allow the students to later assume a role within that community. This conception of authentic activities allows investigation of the experiences of students on co-op placements, to determine whether the students can learn about language, thinking practice and social interactions in the community in which they are placed.

In summary, constructivism remains a useful way of thinking about learning in science and included in a sociocultural perspective. In the tertiary education environment, the student/learner is exposed to socially-mediated ideas within the university, with which, both as an individual and in a social sense, the learner can construct their knowledge. In a co-op programme the student gets the opportunity to test their constructions in the workplace context and gain exposure to a different type of scientific community, that of the workplace practitioner. The impact of the sociocultural context on the learning in the placement (Cobb, 1994), and the difference between the world of the science student and science practitioner (Bereiter, 1994; Roth, 1995) add to the complexity of the attempt to understand how students learn in co-op programmes.

3.5.2 Learning in Technology

As with science in the previous section, it is pertinent firstly to examine what technology is, as its use in common language has made its conception somewhat difficult. Indeed for many, science and technology are one and the same, and it is only in the second half of the 20th century that technology has received greater recognition as an independent entity (Layton, 1988). Part of the difficulty has arisen, as with science, from a description of what exactly technology is. Characterisations include an early conception of technology as applied science (Gardner, 1995; Jones & Carr, 1992; Layton, 1993); as "a form of activity that is fabricative, material product-making or object-transforming, purposive, knowledge-based, resource-employing, methodical, embedded in a sociocultural-environmental influence field, and informed by its practitioners' mental sets" (McGinn, 1978, p. 190); and technology as objects, knowledge, process, volition, artefacts, resources in a socio-technical system (Layton, 1988). But as Gardner

(1995) pointed out, technology as a concept has been difficult to define, and appears to have common usages involving concepts of artefacts, techniques, improvement and systems. Others have distinguished science and technology in terms of their purpose: science striving to explain natural events and phenomena, while technology addresses solutions to practical problems (Driver et al., 1996)

These difficulties as to the precise nature of technology have also clouded understanding of the relationship between science and technology. Gardner (1995) argued forcefully that technology is not merely applied science, and that historically there have been many examples in which technology has been shown to precede science, just as science often precedes technology (Burns, 1990). Gardner's (1995) historical and philosophical review of the science/technology relationship asserted that the tradition of teaching technology as applied science needs to be revised. Rather, the review contended, science and technology should be viewed as "autonomous fields with their own distinctive ways of working", and as representing "interacting communities of people who learn from each other but who hold to differing sets of values" (Gardner, 1995, p. 21). This view was also suggested by Layton (1988), who asserted that there are many examples in history of the "complex interactive, symbiotic and egalitarian relationship between science and technology" (p. 369).

These difficulties with how to conceive of technology have led to uncertainty as to how to incorporate technology learning into curricula. Traditionally technical education in areas such as metalwork, woodwork and technical drawing were seen as subjects in which 'technology' was learnt. As the more recent view of technology emerged in the school system, educators initially tried to fit it into other existing discipline areas such as science and technical subjects (Brusic, 1992; Burns, 1990; Jones, 1997). Movements such as the Science-Technology-Society in the USA and the UK and the Learning in Technology Education Project in New Zealand (Jones & Carr, 1992) went some way towards encouraging the development of technology as a curriculum subject in its own right. In New Zealand publication of the *New Zealand Technology Curriculum* in 1995 (Ministry of Education, 1995) led to technology becoming recognised as a stand-alone subject in New Zealand schools.

As a consequence of its relative youth and uncertainty as a curriculum subject there is a dearth of research and discussion in the theory of learning technology, particularly in comparison to science education. As noted earlier, researchers are, not surprisingly, tending to ally technology learning to recent theoretical ideas such as sociocultural perspectives. It has been argued that central ideas of technology such as problem-solving and collaboration require social behaviour in a defined cultural context, key elements of the sociocultural view (Hennessy & Murphy, 1999). These authors suggest that the Vygotskian emphasis on talk or language in learning is critical for collaborative problem-solving, whereby talk enables scaffolding, a process by which participants are moved "on to ways of reasoning which an individual can understand but not construct" (Hennessy & Murphy, 1999, p. 4).

Learning in technology is also clearly bounded by context, as by its very definition it requires a focus on a particular artefact or process. Such contextualisation argues for learning to be viewed as situated and authentic (Hennessy & Murphy, 1999). Hennessy and Murphy (1999) argued that students learn to solve technological problems when they have learnt how to collaborate through guided participation (Rogoff, 1995) that facilitates involvement of the students in the activity. Guided participation is seen not to be equivalent to instruction, but to indicate the joint construction of understanding through shared thinking between the student and the more expert facilitator (Hennessy & Murphy, 1999).

Additionally technology education lends itself to an experiential approach to learning (Brusic, 1992; Zuga, 1991), in which learners develop approaches to problem-solving that are mediated by conceptualisation and reflection. The provision of opportunities for learners to actively engage in solving real or simulated technological problems is grounded in the notion that technology is experience-based and centred on people.

In summary learning in technology is a relatively new and unexplored area. Links have been made between the purposive acts that constitute technology practice

and the contexts in which they occur to ally sociocultural views of learning to technology learning. The emphasis in technological practice on solving real-world problems means the context is critical to consideration of the learning that could occur. The notion of collaboration being fundamental to technological practice emphasises its socially-shared nature, and values the role of language and talk in learning how to practice. Language and talk therefore mediate the engagement of learners in a shared undertaking in which processes of the trialling and fine-tuning of products and solutions leads to an experiential approach bounded by the sociocultural context. An examination of such an approach may prove to be useful when looking at how students learn technology, and how they learn to become technologists through work placements.

3.6 Summary – Theoretical position for this thesis

It is proposed that sociocultural views of learning, with their emphasis on the social, cultural and historical contexts for learning, and the focus on situated learning, distributed cognition and mediated action, are a useful way of analysing and theorising about learning in co-op placements. An understanding of learning in co-op placements underpinned with theory is important for political, curriculum and pedagogical reasons.

Co-op placements situate students alongside practising professionals in an area of endeavour that is commensurate with their classroom studies, for example, science and technology. According to the sociocultural views of learning, such students can be seen as within a science and technology community of practice, in which learning is situated, distributed, and occurs by participatory activity that is mediated through tools such as language and artefacts (e.g. instrumentation, computers). Learning in work placements can be conceived of as apprenticeship in which both a student's manual and cognitive faculties may be developed. Learning may be facilitated by engagement in authentic activities embedded in a sociocultural context.

Adopting a sociocultural view of learning recognises the importance of the context in learning. This reveals the possibility of understanding the setting of the

university as distinct to that of the workplace, and permits a view of learning occurring in each setting which is different but equally valid. An espoused goal of co-op programmes is the integration of classroom and workplace learning, in which learning in each setting informs and complements the other, and it would be important for research into learning in co-op programmes to investigate whether, and how, this integration occurred.

Acknowledgement of the appropriateness of sociocultural views of learning for an examination of student learning through work placements focuses the research onto aspects of the student experience that have a social and cultural dimension. As such it is important that research investigates the impact of contextual factors such as social interactions at work, the use of language at work, and the culture and context of the workplace on student learning. Inquiry would therefore focus on how the placement opportunity affects a student's conception of what it means to do science/technology, and allow some investigation of how that learning may help a student make the transition between the worlds of the science/technology student and that of the science/technology practitioner. Recent theorising in science and technology education would also suggest that a view of learning as a social process in a culturally-determined community of practice is a fruitful way to explore learning through co-op work placements in science and technology.

The next chapter poses the research questions that guided the study in this thesis and describes how the study was carried out.

Chapter 4 Methodology

4.1 The research questions

As discussed in the first three chapters, there is a need for research into student learning in co-op placements that is underpinned by learning theory. This research is needed to inform curriculum and pedagogical planning of co-op programmes, and to underscore the educational value that such programmes have. This study contributes to that research need by addressing the following questions:

1. What and how does a student learn through cooperative education work placements in science and technology?

2. What roles do the work placements in cooperative education programmes play in facilitating the transition from student to practitioner of science and technology?

This chapter provides a description of how the research in this study was conducted. It provides background to the methodological approach used in the research, and the methods chosen for data collection and analysis. It also discusses issues of trustworthiness and ethics. A description of the research design concludes the chapter.

4.2 Methodology

Methodology has been defined as the "overall strategy for resolving the complete set of choices or options available to the inquirer" (Guba & Lincoln, 1989). It is the position from which the researcher approaches the study. It has an affinity with the questions being studied, it indicates the tools for data collection and it pervades the data analysis.

The choice of methodology is based on the questions to be asked and appropriateness to the purpose of the inquiry (Patton, 1990). Historically research

in the education field has been conducted under what is known as the positivist paradigm (Cohen, Manion, & Morrison, 2000; Guba & Lincoln, 1994). The origin of the positivist approach has been ascribed to the nineteenth-century philosopher, Auguste Comte, and led to a doctrine that knowledge is based on experience and can only be augmented by observation and experiment (Cohen et al., 2000). The positivist approach was first applied to study of the natural and physical sciences and is still the methodology used in this arena. This has led to scientific methods that seek to investigate natural phenomena in an objective way, that treats reality as an object that can be examined impartially and subjected to generalization into laws that can explain (eventually) all nature. In other words, the paradigm asserts a realist ontology, an objectivist epistemology and an experimental and manipulative methodology (Guba & Lincoln, 1989).

This positivistic stance has also been applied to education and other social science research for many years (Burns, 1994; Cohen et al., 2000), including cooperative education. This approach dictates assumptions that social phenomena can also be explained in objective, law-assemblies. However there are criticisms of these assumptions and an increasing recognition that phenomena such as learning cannot be investigated by scientific methods and assigned to universal laws (Cohen et al., 2000; Denzin & Lincoln, 1994; Habermas, 1972). These criticisms include: that the positivist approach focuses too much on the visible behaviour that can be objectively observed, whilst ignoring the subjectivity and intent of the individual; that it fails to acknowledge the individual's ability to interpret their own experiences and act according to their interpretations; that it fails to account for the reasons behind the observable behaviour; and that context is not accounted for (Cohen et al., 2000; Denzin & Lincoln, 1994; Guba & Lincoln, 1994). These deficiencies have also been expressed regarding previous research into learning in co-op programmes (see Section 2.4.2).

It is this dissatisfaction with the positivist approach that has led to the development of new approaches to inquiry often termed naturalistic, conceiving that the research setting is natural and not manipulated (Cohen et al., 2000; Lincoln & Guba, 1985; Patton, 1990). These approaches characterise the existence of multiple, subjective realities that are open to interpretation rather than

a single, objective reality that is knowable, and delve into the experiences of people in context (Shulman, 1997). Such an approach has been termed the interpretivist paradigm (Cohen et al., 2000) in which researchers "begin with individuals and set out to understand their interpretations of the world around them" (p. 23). Whilst the study can be guided by a framework, but not a hypothesis, theory emerges from interaction of the data and the researcher's mind and, unlike the positivist approach, the study does not necessarily set out to verify or falsify theory.

Critics of the interpretive paradigm argue that subjective, meaning-focussed methods lack verification, and fail to deliver generalizable information that could be used to enhance understanding of social phenomena. These issues of validity and reliability are viewed differently in positivist and interpretive research, and are discussed in more detail in Section 4.5 in this chapter. A further criticism is that interpretive research can isolate the situation in which the researcher is located, and issues such as power structures that relate either to the situation or the researcher, that may influence participants, are not accounted for (Cohen et al., 2000). Proponents of interpretive research would argue that this criticism can be overcome by detailed description of the contextual situation and acknowledgement by the researcher of their own position, power etc when analysing their data and reporting their research.

As a researcher my own previous education was in the science field (Coolbear, Eames, Casey, Daniel, & Morgan, 1991) and I had been schooled in logical-positivism. This background suggested a quantitative approach for this study in which I would pose questions that could be verified or falsified by scientific methods, filled with statistical data collection under rigorously-controlled and replicable conditions. However, it became readily apparent to me that subjecting the learning experiences of a range of individuals in a variety of different contexts to this type of scrutiny was going to be difficult, if not impossible. The diversity of placement opportunities afforded cooperative education students, and the diversity of placement types across cooperative education programmes would make generalising quantitative outcomes within and across programmes very problematic.

With a positivist approach, in order to answer the first question about learning I would have had to hypothesise that learning occurred in a certain way and set out to test that, but trying to account for variability in experiences, perceptions and contexts would have made data interpretation imprecise. To answer my second question about learning to become a scientist or technologist I would need to test the students' understanding of practising science and technology against a normative view. There would be difficulty in that undertaking too, as finding a consensus on what it means to practise science and technology across a variety of research and industrial contexts would be hard. Finally, it was the students who were becoming the practitioners, not me. It was important that it was the students who provided the data, that it was *their* perceptions of what was learnt, and how, and who from. I needed to be able to access their meanings of the experiences and interpret them.

It made sense to look for an alternative that would allow examination of learning outcomes and process through the eyes of the students. This would express their meaning of their experiences, and permit an incorporation of the context into the research, providing for 'thick description' (Denzin & Lincoln, 1994; Geertz, 1973; Merriam, 1988). The interpretive paradigm encompassed these features and allowed the use of open-ended questions that would permit consideration of all answers and the distillation of them into an understanding of student learning in work placements. This methodology also sat well with the notion of sociocultural learning, based as it is on participants' experiences of the social and cultural environments in which they are placed. For these reasons an interpretive methodology was used in this study.

4.3 Methods

The choice of methodology dictates the selection of tools or methods of inquiry in that the method(s) chosen must be capable of providing data that can be analysed in a manner commensurate with the methodological approach. The positivist approach favours methods that allow for variables to be controlled for, correlations observed and conclusions drawn. Methods often used include

experimentation, observation and surveys. These methods can provide quantitative data that can be treated statistically to examine correlations, to quantify confidence in conclusions drawn, and verify or falsify theory.

The interpretive approach favours methods that examine meaning and context, that allow a picture of the subject to be seen. Methods such as interviews and participant observation are often used. These methods provide qualitative data that can be examined and interpreted to make sense of the individual's experiences. This apparent dichotomy between positivist-quantitative and interpretive-qualitative is not absolute. Whilst it is less common that positivists will use qualitative methods, interpretivists will use quantititative methods. Indeed many researchers (e.g., Patton, 1990) advocate a mixture of quantitative and qualitative methods to provide a broad base to the data gathered, and each type of method has advantages and disadvantages.

Quantitative methods "require the use of standardised measures so that the varying perspectives and experiences of people can be fitted into a limited number of predetermined response categories to which numbers are assigned" (Patton, 1990, p.14). This has the advantage of being able to measure large samples and sum the data into a statistically-challenged set of generalizable findings, but has a tendency to over-simplify relationships between variables and ignore context.

Qualitative methods allow issues to be studied in depth and detail as the researcher is not constrained by searching for data to fit predetermined categories of analysis (Patton, 1990). This tends to produce a lot of information on a small sample which gives detailed data on those cases but reduces generalizability.

Quantitative and qualitative methods also differ in the way they achieve validity. In quantitative methods, validity is dependent on ensuring that the instrument being used to measure variables is actually measuring those variables. In qualitative research, "the researcher is the instrument" (Patton, 1990, p. 14) and validity depends on the ability of the researcher. This issue is covered in more detail in Section 4.5.

In this study qualitative methods were the most appropriate for investigating the meanings that students made of their learning experiences on their work placements. Patton (1990) has summarised the elements of a qualitative inquiry:

1. Naturalistic inquiry – studying a real-world situation in a non-manipulative way.
2. Inductive analysis – use of open questions to allow emergence of categories of analysis from the detail of the data, but at the same time acknowledging that the questions posed are based on the researcher's mind.
3. Holistic perspective – the whole phenomenon under study is examined for its contribution to understanding.
4. Qualitative data – detailed, thick description is gathered with the use of data given directly from people's experience and perspectives.
5. Personal contact and insight – the researcher has direct contact with the people, situation and phenomenon under study.
6. Dynamic systems – attention to process and change in the study.
7. Unique case orientation – assumes each case is special and unique and includes within-case and cross-case analysis.
8. Context sensitivity – places findings in a social, cultural and temporal context, and de-emphasises generalizability.
9. Empathic neutrality – recognition that the researcher is part of the study and makes a contribution through their own experience whilst remaining neutral.
10. Design flexibility – allows for adaptation of the inquiry and pursuit of new paths as they emerge (Patton, 1990, p. 40).

These elements resonated well with the questions being asked, the purpose of the inquiry and the interpretive approach. They would allow a detailed investigation of individual students' learning experiences in the context of the workplace over the course of their degree programme.

This study employed predominantly qualitative methods. An initial survey was conducted followed by a longitudinal study using interviews and small case studies.

4.3.1 A preliminary survey

Surveys can include structured or semi-structured interviews, questionnaires, standardised tests and attitude scales (Cohen et al., 2000). Surveys can produce standardised numerical data that can be statistically analysed for correlations, but can also provide some open responses, which give descriptive data which can be quantified. The survey used in this study employed questionnaires.

The questionnaire offers the advantage that the instrument can be used to survey a large number of people within a short time period. It can be mailed or administered in person, and can be administered, and even to a certain extent, data-analysed by more than one person with little concern about researcher variability. Questionnaires may contain either closed, structured questions or open, unstructured questions, or both. Closed, structured questions are best when the sample is large, there is a finite range of responses required, and statistical analysis will be used; that is, quantitative data are produced. Open, unstructured questions are best when the sample is small, the range of responses is unknown, and meaning is being looked for; that is, qualitative data are produced.

In this study the questionnaire was chosen to allow collection of data from a large sample of individuals, who lived in all parts of New Zealand, making interviews logistically problematic. The questionnaire included both open questions that gave some qualitative data to interpret, and closed questions that gave some quantitative data that could be statistically analysed to examine for correlation of the variables mentioned earlier.

4.3.2 Interviews

A method commonly used in qualitative inquiry is the interview. The interview allows for the interviewee to disclose what is in their mind, to find out about things that cannot be observed. Qualitative interviewing assumes "that the perspective of others is meaningful, knowable, and able to be made explicit" (Patton, 1990, p. 278). Interviews allow an opportunity to clarify responses, probe the respondent and cover an issue in depth (Jaeger, 1997). For example, they have

proven to be useful as tools to investigate children's learning in science (Bell, 1995; Bell, Osborne, & Tasker, 1985).

The challenges of the interview method are several. The interviewer needs to "establish 'balanced rapport': on the one hand being casual and friendly, but on the other hand, directive and impersonal" (Fontana & Frey, 1998, p. 52). The interviewer also needs to develop "a style of 'interested listening' that rewards the respondent's participation but does not evaluate the responses" (Fontana & Frey, 1998, p. 52). Patton (1990) also makes this point when he describes the need to establish rapport with the person whilst maintaining neutrality with respect to what the interviewee says. Fontana and Frey (1998) have commented on the role of the researcher as interpreter of the interview data and have emphasised the need for openness and reflexivity on the part of the researcher on their own role in influencing the interview process.

There are several mechanisms for interviews including telephone interviews, face-to-face and group interviews. In this study face-to-face, one-on-one interviews were selected as the method as they allowed direct rapport with the participants, feedback to be gained through observation as well as dialogue (Jaeger, 1997), and individual contextualisation which may have been smothered in a group situation. As Patton (1990) points out the success of this type of interview is very dependent on the interviewer. Others caution that critics of interviewing find the subjective relationship between the interviewer and the interviewee problematic, asserting in particular that the nature of the power/authority between the two could influence the data (Erickson, 1998). I was particularly concerned with the issue of power, given my visible position of authority vis-à-vis the students as placement coordinator within the University. I was at pains to minimise the imbalance that may have existed and strived to establish a researcher's rapport in the early interviews. I was very careful to separate my role as a researcher from my role as coordinator during interviews conducted in the workplace, and to be open and unresponsive to criticisms levelled at my programme by some participants.

There are also several types of interview, which have been described on a spectrum of formality from formal/structured interviews, to semi-structured

guided interviews to informal conversational interviews (Cohen et al., 2000; Patton, 1990). The formal interview relies on the same questions being asked of each participant and is often used in situations in which several interviewers are employed to collect data, the notion being that greater consistency can be gained by regularising the questions. This approach can provide data that is easy to categorise but it reduces the opportunity to explore issues in depth or pursue unexpected tangents that might arise in the interview.

At the other end of the spectrum the informal interview permits great flexibility during the interview to pursue issues that arise. It allows highly individual interviews that are embedded in the context and the relationship between the interviewer and the interviewee. Its weakness is that it often elicits unsystematic information that can be difficult to code or compare, and is more open to interviewer effects.

The semi-structured or guided interview contains elements of both of the above. It permits some flexibility but also some control, providing some systematic data collection across a number of participants, whilst allowing exploration of individual issues as they arise (Kvale, 1996). This style of interview was chosen for the study for these reasons. The semi-structured interview with a set of topic questions to ask would gather some across-case data but would still allow flexibility in the conversation, and would allow for open dialogue about the key issues of interest. It would also allow tailoring of the interview to the particular workplace and the student.

4.3.3 A longitudinal study

The research questions for this study were partly focussed on transition and hence process, and therefore it made sense for the research to be transitional as well, in other words to be a longitudinal study. This would allow the study to follow a cohort of students through their degrees and examine the learning that contributed to the transition along the way.

Longitudinal studies have the advantage that development can be studied over time (Arzi, 1988; Keeves, 1998; Sprod, 1997). They are based on a time variable, in which data is collected on several occasions from the same subjects at prescribed times. They may also include a participant age variable, in which data is collected across a range of subject ages at one time (also described as cross-sectional) (Cohen et al., 2000; Keeves, 1998). The time variable could also be a disadvantage to the researcher as difficulties can arise with retaining subjects within the study over a long time period, also termed sample mortality (Cohen et al., 2000), and the sustainability of a long-term project (Arzi, 1988). Cohen et al. (2000) also raise the difficulty of "the 'control effect', where repeated interviewing can sensitise participants to issues being raised, thereby bringing undue focus upon them" (p. 176). It is uncertain whether this is actually a disadvantage of the method, as such focussing could in fact perform a reflective role, particularly when semi- or un-structured interviews are employed. Despite this uncertainty, as Arzi (1988) points out, longitudinal studies offer great potential to "elucidate long-term educational processes and outcomes" (p. 17), and many studies have been conducted in this way (Northfield, 1993; Subotnik & Arnold, 1994), but not many have been carried out at the tertiary education level (Fitzsimons, 1997; Kidd & Naylor, 1991). In the co-op literature, a good example is a study on the development of mentoring relationships during student placements (Ricks & Van Gyn, 1997). This study used questionnaires to look for evidence of mentoring for a cohort of co-op students as they passed their co-op programmes.

In this study the longitudinal process of the study opened the way for multiple interviews with each participant in which previous experiences and perceptions reported could be re-visited. This allowed for changes to be explored, and performed a type of triangulation function, helping to ensure greater validity and reliability in the data (Cohen et al., 2000) (see Section 4.5).

4.3.4 Case study research

The case study has been defined as an examination of a specific phenomenon that provides a rich, thick description of a bounded case that enhances understanding

and leads to generalizations arising from the data (Merriam, 2001). It can focus on a multitude of variables and determine change over time, therefore being well-suited to longitudinal studies. Case studies lend themselves to qualitative research, as this research approach is based upon the objective of understanding the meaning within experience. They allow an in-depth, holistic view of the person or group under study.

In this study, the case approach was used to delve deeply into the learning experiences of some of the participants, providing a complex and intricate view that illustrated a particular view of reality in that case. Those cases were interpreted for their fit with the thesis being developed across all participants.

4.4 Data handling and analysis

Goetz and LeCompte (1984) state that the first step in data analysis should be to review your research questions. This provides the researcher with a reminder of the reasons for the research and the audience for which the research is intended. Once this is considered, attention can turn to ways of handling and analysing the data produced by the research.

One of the difficulties of qualitative research, and interview methods in particular, is that they can generate large amounts of data, a situation that has been termed data overload (Cohen et al., 2000). There is then a need to reduce the data to a manageable size (Lemke, 1998; Miles & Huberman, 1984). This must be done however in the face of what has been described as the tension between "maintaining a sense of holism of the interview and the tendency for analysis to atomise and fragment the data" (Cohen et al., 2000, p. 282). This is typically done through the use of coding during content analysis.

Content analysis involves "identifying, coding and categorising the primary patterns in the data" (Patton, 1990, p. 381). Cohen et al., (2000) suggested that there are several stages of analysis for interview data, which generate meanings, classify and order these meanings, and then interpret the meanings. In their detailed look at qualitative data analysis, Miles and Huberman (1984) identified

12 specific stages of generating meaning, including noting patterns, making metaphors, identifying and noting relationships between variables, and emphasised the importance of coding. However, Kvale (1996) also described a number of meaning generation methods from transcripts but concluded that most researchers probably use what he calls "an ad hoc use of different approaches and techniques for meaning generation" (p. 203).

As Patton (1990) pointed out, the use of an interview guide can become an analytical framework for analysis. In this study, the interview guide became the tool that guided the initial analysis of the transcripts. Categories and codes emerged from that framework and were modified as the analysis progressed. As the periods of data gathering were separated by some months, brief analysis of each set of interviews prior to the next set being conducted allowed refinement and refocussing of questions, which has been noted by Merriam (1988) as reducing repetition and enhancing parsimony in data collection.

The first stage involved within-case analysis to reduce the data (Miles & Huberman, 1984) down to a series of case studies which I then analysed in-depth. This data reduction involved searching the transcripts for quotes that would provide evidence for the students' perception of their learning. These quotes were compiled into case studies for each student and categories emerged for quotes of similar themes. Some of these categories were based around the theoretical framework while others emerged from the data. The individual case studies built up a picture of individual variation (Patton, 1990) and provided rich, deep data with thick description (Merriam, 1988).

The second stage of data analysis involved a cross-case study within categories. This involved interpretation across individuals looking for similar meaning in their experiences, using categories that either emerged from the data, or were derived from the interview guide framework. This stage led to "higher level, overriding and integrating conceptualisations" (Glaser & Strauss, 1967, p. 36) emerging in an intuitive yet systematic manner (Goetz & LeCompte, 1984).

Interpreting the data meant considering it in the light of sociocultural views of learning as discussed in Chapter 3, but also taking into account my own experience with students in the placement programme. This experience had provided me with a knowledge and understanding of their potential experiences from an observer's perspective, and permitted some richer interpretation of the context of the students' perceptions.

4.5 Trustworthiness: Issues of validity and reliability

Research can be broadly defined as systematic inquiry (Merriam, 1988) conducted in a rigorous manner. The worth of research has traditionally been measured in terms of its validity and reliability. Within the positivist paradigm four criteria have been used in value judgement: internal validity, external validity, reliability and objectivity (Altheide & Johnson, 1994; Cohen et al., 2000; Lincoln & Guba, 1985; Merriam, 1988). Internal validity refers to the "extent to which variations in an outcome (dependent) variable can be ascribed to controlled variation in an independent variable" (Lincoln & Guba, 1985, p. 290) or in other words, "how one's findings match reality" (Merriam, 1988, p. 166). External validity refers to the "extent to which the findings of one study can be applied to other situations" (Merriam, 1988, p. 173), in other words their generalizability (Cohen et al., 2000). A precondition of external validity is internal validity, as it is not feasible to generalize meaningless data (Lincoln & Guba, 1985). Reliability refers to the consistency and replicability of the study, the extent to which the findings could be replicated across time, across methods, and across samples (Cohen et al., 2000; Lincoln & Guba, 1985; Merriam, 1988). Reliability is also a precondition for validity (Lincoln & Guba, 1985). Finally objectivity refers to the extent that the findings are influenced by the researcher, striving in the positivist manner for minimising any such influence (Lincoln & Guba, 1985).

Application of these four positivistic criteria to interpretive research creates serious complications. Alternative conceptions to establish the trustworthiness have been suggested to account for these difficulties and these are discussed in the following sections.

4.5.1 Qualitative internal validity: An issue of credibility.

A key problem with internal validity providing a match to reality is that qualitative research is based on people's constructions of reality (Merriam, 1988), and acknowledges that there is "a multiple set of mental constructions...made by humans" (Lincoln & Guba, 1985, p. 295). The task of the qualitative researcher is then to represent those constructions adequately for the research to be deemed credible. Credibility is created by (1) carrying out "the inquiry in such a way that the probability that the findings will be found credible is enhanced", and (2) by demonstrating "the credibility of the findings by having them approved by the constructors of the multiple realities being studied" (Lincoln & Guba, 1985, p. 296).

Lincoln and Guba (1985) suggest several techniques that can be used to increase credibility in a qualitative, naturalistic study: prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis, member checks and progressive subjectivity. Prolonged engagement in the field allows the researcher to become more familiar with the setting, and to build rapport and trust with the participants, which helps identify spurious, unrepresentative information (Lincoln & Guba, 1985). Persistent observation allows identification of the important elements in the study and for detailed focus to be applied (Lincoln & Guba, 1985).

Triangulation is a technique that involves the integrative use of several elements in the collection of data. There are several types: data source, methods, investigators, theories, time and space (Cohen et al., 2000; Lincoln & Guba, 1985; Merriam, 1988; Patton, 1990). Data source triangulation involves the use of multiple participants providing one sort of data in one sense, or a participant (or participants) providing several sources of data (Lincoln & Guba, 1985; Patton, 1990). As Patton (1990) pointed out, these multiple sources often lead to contradictions which, although complicating interpretation, provide greater validity to the data if reasons for the differences can be found. Methods triangulation involves the use of different methods to gather data, and may mix quantitative data with qualitative. This can be particularly effective at reducing

weakness due to a single method. Investigator triangulation is the use of more than one researcher, a technique often used in positivistic studies. This style has the advantage that different researchers may elicit different data, which can add to the breadth of the data gathered, and may reduce investigator bias (Patton, 1990), but a good understanding amongst the research team is essential in order to ensure the data is not irreconciliable (Lincoln & Guba, 1985). Theory triangulation has mixed support. On the one hand it is seen as the data being viewed from the perspective of more than one theory providing the opportunity for wider explanation (Cohen et al., 2000; Patton, 1990); whilst on the other hand theory triangulation is seen as unsound, in that if a given piece of data was claimed to fit more than one theory, this is more likely to establish that the theories are related to each other than establish that the data is accurate in any sense (Lincoln & Guba, 1985). Finally time and space triangulation involves collection of data over time, in a cross-sectional or longitudinal manner, or over space, particularly across cultural boundaries (Cohen et al., 2000).

Another technique that can be used to increase credibility in a qualitative, naturalistic study is peer debriefing. This technique involves the researcher subjecting them-self to a disinterested peer in a manner that might uncover concepts and assumptions that may have been "implicit within the inquirer's mind" (Lincoln & Guba, 1985, p. 308). A further technique used is negative case analysis, which is the continuous revision of a formulated hypothesis in the light of the data until such time as all cases are accounted for (Lincoln & Guba, 1985; Patton, 1990). This technique acknowledges those cases that are different and by attempting to rationalise them with the hypothesis proposed, learns more about the nature of that hypothesis.

Finally member checking has been described as "the most crucial technique for establishing credibility" (Lincoln & Guba, 1985, p. 314). It involves subjecting the data, analysis and conclusions to the participants for their comment. It can be both formal and informal in nature and should occur regularly during a study. The checks provide participants and other stakeholders the opportunity to assess adequacy, intentionality, and to summarize, and gives the researcher the chance to get a critique of the work to date. Finally, progressive subjectivity – the extent to

which the researcher imposes their own view on the reality being investigated, needs to be acknowledged (Lincoln & Guba, 1985). This has also been discussed under the gamut of researcher bias, which includes the view the researcher brings to the research (Merriam, 1988) as well as the way their view develops during the study.

Any study will not in all likelihood utilise all these techniques for enhancing credibility, and it is important to accept that some may be more relevant and achievable than others. Nevertheless, any technique used will tend to increase the rigor of the study.

4.5.2 Qualitative external validity: An issue of transferability

In the quantitative arena, external validity equates to generalizability, the extent to which the findings of one randomly-selected sample can be applied to a similar sample or population, irrespective of its context. The onus is on the researcher to ensure that variables are sufficiently controlled such that any variation in the second sample could be correlated with the first. In qualitative, naturalistic research the sample selection is more often purposeful than random, and therefore may not be viewed as representative. The research focuses on human behaviour and this is by its nature heterogeneous. The onus for validity shifts from the researcher to the reader and the issue becomes one of transferability (Lincoln & Guba, 1985). The user of the findings may then decide if they apply to their own situation (Merriam, 1988). The researcher must provide the "thick description necessary to enable someone interested in making a transfer to reach a conclusion about whether transfer can be contemplated as a possibility" (Lincoln & Guba, 1985, p. 316). In this sense the researcher provides a highly detailed description of the context for the research and of the data itself, often including, in the case of interview data, extensive segments of verbatim transcript.

4.5.3 Qualitative reliability: An issue of dependability

Reliability in the positivist sense indicates consistency and replicability of the data. As Merriam (1988) argues this is problematic in education research "because human behaviour is never static" (p. 170). Positivists seek reliability to confirm

causality and establish laws. But qualitative research seeks to describe and interpret human behaviour rather than form laws about it (Merriam, 1988), and its strength is seen to be in the un-replicability of a unique situation (Cohen et al., 2000). Lincoln and Guba (1985) argued that the notion of replicability, which indicates a tangible and unchanging reality against which the findings can be replicated, is anathema to the naturalist view that such a reality can be not described. They preferred the notion of dependability – that given a clear description of how data was obtained and open acknowledgement of the context, the findings are acceptable within that context. This does not mean that the same results would be gathered in the same setting a second time. In interviewing in particular, different researchers may interpret their data quite differently but no less reliably (Kvale, 1996).

Merriam (1988, p. 172) suggests three techniques to enhance dependability in qualitative research:

1. The researcher should fully describe the assumptions and theory behind the study, their own position with respect to the group being studied, the basis for selecting participants and a description of them, and the social context from which the data were collected.
2. Use of triangulation, particularly multiple methods of data collection and analysis.
3. Establish an audit trail (Lincoln & Guba, 1985) that describes how data were collected, how categories were derived, and how decisions were made throughout the study.

Merriam (1988) also makes the point that reliability in the positivist sense includes examination of the instrument, and that as the researcher is the instrument in qualitative research, the reliability can be improved through training and practice of the researcher.

4.5.4 Qualitative objectivity: An issue of confirmability

Lincoln and Guba (1985) see confirmability as a more appropriate way of describing the objectivity of a naturalistic study. In the same manner as its

positivistic counterpart objectivity, confirmability concerns the influence of the investigator on the data. Whilst a naturalistic researcher cannot be 'objective' by definition of the style of research, confirmability, as well as dependability discussed above, can be enhanced by establishing a clear audit trail in which the reader can judge for themselves the potential influence of the researcher.

4.5.5 Trustworthiness issues in interviews

The use of interviews as a data gathering method raises a number of issues germane to the trustworthiness of the inquiry (Cohen et al., 2000). Firstly interviewer bias can play an important part in an interview and this should be acknowledged, at the same time that it is recognised that interviewer neutrality is impossible. Secondly the use of open-ended questions provides for greater recognition of interviewee individuality in responses and may increase the dependability of the data. Thirdly leading questions should be used judiciously with an awareness by the interviewer of when they are being used and an acknowledgement of this usage when interpreting responses. Fourthly the issue of power in the interview should be considered. Power may reside either with the interviewer or the interviewee and steps should be taken to minimise any imbalance during the interview (Cohen et al., 2000). Finally the selection of excerpts of transcript used as data to support findings needs consideration. Erickson (1998) argues that the researcher has "tremendous executive power in the selection of transcript quotes and that this needs to be made clear to the reader" (p. 1171).

4.5.6 Summary of trustworthiness

Naturalistic/qualitative research demands a different approach to the issues of validity, reliability and objectivity that prevail in positivistic/quantitative research. Other concepts such as credibility, transferability, dependability and confirmability are more appropriate.

The trustworthiness of a study is in the eyes of the reader and the researcher can only attempt to persuade the reader through careful use of techniques as described

earlier (Lincoln & Guba, 1985). The following section describes measures taken to enhance the trustworthiness of this study.

4.5.7 Trustworthiness techniques used in this study

Following the discussion above, certain steps were taken in this study to enhance its trustworthiness. By the use of multiple interviews over a period of two years, data was collected which had the potential to show change. This 'persistent observation' helped me to identify the important elements of the constructed realities of the participants, and to focus the study. The multiple interviews also performed a time triangulation function in that I was able to re-visit what any participant had previously said and probe for any change in subsequent interviews. The existence of change or stability in their viewpoints became valuable data to examine.

Triangulation was also performed in the first placement with the use of journal-writing by the students. It was hoped that the use of a journal may encourage some ongoing and timely reflection by students on their learning (Morrison, 1996). Each student was given a journal at the beginning of their first placement with a series of prompt questions on the inside cover. The students were asked to reflect on these questions, that were directed towards their learning on placement, whenever they felt able to. Each student's journal entries were examined for consistency with their views expressed in interviews and were used to augment data collected in interviews.

Negative case analysis was performed during the analysis phase. Member checks were carried out by having the participants validate their transcripts and by giving them the opportunity to comment on the research findings. Participants were asked to read their transcripts and to submit any changes they wished to make. The opportunity for participants to examine and comment on how I had interpreted their meanings, and used excerpts of their transcripts as evidence, goes some way to alleviate Erickson's (1998) concerns about the power residing in selection of transcript excerpts.

In order to permit transferability a thick description is provided of the setting for the research, the individual contexts and the individual participants. In some cases these have been summarised for the sake of parsimony, without compromising the intent of the description.

Further steps to enhance the trustiworthiness of this study included using the notion of dependability (Lincoln & Guba, 1985) in describing clearly how the data was obtained and acknowledging its context for the reader to judge. Following Merriam (1988), descriptions are given of the assumptions and theorising behind the study (Section 3.2), acknowledgements of my own position with respect to the group being studied (Section 4.7), descriptions of the participants (see Appendix A) and how they were selected (Section 4.8.2), and description of the contexts from which the data arose (Section 7.2). I have employed triangulation and provided an audit trail of how the data was treated (Section 4.4).

In the use of interviews I recognise that I came to the study with ideas gathered from my previous experiences with co-op students. There is little doubt that these ideas influenced the questions that I asked, creating the possibility that I ignored other questions. Wherever possible I employed open-ended questions to allow freedom of expression. For the same reason I avoided leading questions in the early interviews and only employed them sparingly to increase focus in the latter half of interviews towards the end of the study.

One potential limitation of the interview technique that I was aware of was its potential inability to expose tacit knowledge. Broadly speaking tacit knowledge is that which cannot be explicated and I was concerned that a short interview may not allow students to express all the learning that they achieved. Three factors mitigated against this concern: firstly an assumption can be made that students would report on the learning that is most significant to them, and as the study was focussed on their constructions of reality, this was reasonable; secondly the member checks provided the students with an opportunity to reflect back in hindsight and confirm or alter their views; thirdly, prolonged engagement with the students through a series of interviews provided multiple opportunities for

discussion of their learning, reducing the chance of not examining key aspects of their learning.

4.6 Ethical considerations

Qualitative educational research requires an examination of people's lives. Furthermore interviews, as noted earlier, ask for disclosure of ideas and thoughts from the interviewee. Herein lie potential dangers for the researcher and the researched. As Patton (1990) points out, interviews are interventions that expose reflection on the interviewee's inner-self. This can lead to potential for harm which may be unethical. Ethical concerns in educational research occur in four main areas: access to participants, informed consent, the right to privacy, and protection from harm (Cohen et al., 2000; Fontana & Frey, 1998; Kvale, 1996).

Access to participants includes both access to the location of the participant group(s), and recruitment of the individual participants. Informed consent implies that potential participants are free to choose whether or not to participate in the study after having been fully informed of the process of the research within which they have been invited to participate (Cohen et al., 2000). The right to privacy is associated with not only protecting the identity of the participant, but also with the confidentiality of the data gathered on that participant. The notion of protection from harm relates to care being taken to ensure that participation in the study does not adversely affect the individual in any way.

Permission for this study was gained from the Human Research Ethics Committee in the School of Science and Technology at the University of Waikato. Access to participants was gained by virtue of permission from the Cooperative Education Unit that administers the BSc(Tech) programme. Participants were recruited as described in Section 4.8.2, and were given the right to decline participation or withdraw from participation at any stage of the study. Potential participants were given full information about their role in the study and were asked to sign an informed consent form after agreeing to participate. Participants were also asked to inform their employers whilst on their workplaces of their participation in the study. The study protocol required the participants to find time during their

workday to have an interview. A further issue of concern was the potentially confidential nature of the work being undertaken by the student, and the student was advised prior to conducting the interview to discuss with their employer what they could or could not reveal about the nature of their work. This only became an issue in one case.

Participants in this study were assured of anonymity. Steps taken to ensure this included not revealing participants' names to anyone else, the use of a pseudonym for each participant in discussing their experiences, the use of a code name on all transcripts, quotes used and other data pertaining to them. Excerpts appearing in this thesis have been coded according to the participant's name, the interview number for that participant and the page number of the transcript of that interview. All data gathered from the participants, including taped interviews and transcripts were kept in a locked place. Participants were given right of access to any information and data gathered from them at any time of the study.

All issues raised with the participants and their views were treated confidentially throughout the study. As Patton (1990) points out, it could be easy to become drawn into ethical dilemmas during an interview when the interviewee reveals something that requires action. This was particularly a concern in this study as the participants knew me not only as a researcher but also as a placement coordinator, and as such someone who has authority in the University. On two occasions this caused me problems when I became aware of issues in the placements, which I had to be very careful in addressing with the participant concerned. I always tried to separate my role of researcher from that of coordinator, an issue discussed by Kvale (1996).

Potential harm to participants rested primarily in obstruction of their educational opportunities and their relationship to their employer. I took care not to influence the process of finding a placement for the students involved, and not to disrupt the progress of the placement once underway. I provided no information to any other coordinator about the student's feelings and experiences in the workplace, so that such information could not influence the assessment of the student's placement. Equally I provided no such information to the student's employer.

A further consideration that I had was that I acted as examiner for biology BSc(Tech) students in my role as placement coordinator. To avoid potential conflict with this role I excluded all biology students from the study. This effectively precluded any examination of student learning in biological placement contexts. In general terms these contexts are similar to those experienced by the subject majors included in this study, but it is possible that the exclusion of biology majors from the study has some effect on the study findings.

4.7 The research design

The collection of data comprised two phases. The first phase was a survey of BSc(Tech) graduates' perceptions of their learning while on their work placement. This phase provided some basis for questions to be used in the interviews. The second phase was the longitudinal study of a cohort of current BSc(Tech) students as they passed through the placements stages of their degrees.

4.7.1 The graduate survey design

A questionnaire was designed and then piloted (using three recent graduates of the BSc(Tech) programme) to check for validity, reliability and practicability of the questions (Cohen et al., 2000). It was then posted out to 125 graduates who had completed placements within the BSc(Technology) programme as part of their undergraduate degree. These 125 graduates were selected on the basis of knowledge of their whereabouts and so retained some bias because of this. The sample of 125 graduates had completed their last placement between 1989 and 1997, the sample being 29% of the BSc(Tech) graduate population over that period. The remainder of the BSc(Tech) graduate population over this period were un-contactable due to their addresses being unknown.

As described in Section 1.3, students in the programme generally carry out at least two placements, so graduates were asked to consider only their last placement in the programme when answering the questionnaire, as responses may have differed between their placements. This potential variation was a weakness of this method

of data collection, which was addressed in the later longitudinal study, in which students were studied across both their placements.

The questionnaire sought background information about the placement, asked for open responses of perceptions of learning from a what, how and who perspective, examined some detail on learning of working knowledges (Simon, Dippo, & Schenke, 1991) such as theory, skills, language and relationships, and sought views on assessment of the work placement. The questionnaire is documented in Appendix B.

The questionnaire contained a mix of open, qualitative and closed, quantitative questions. The graduates were asked open questions early in the questionnaire to elicit whatever first came to their mind about their learning. Their qualitative responses were coded and categorised in an interpretive manner, providing a list of learning outcomes and processes. Relative frequencies of outcomes and processes reported were quantified. Examples of open responses were also recorded verbatim. These were coded as (Gnumber), where refers to graduate and the number refers to respondent from whose questionnaire the data is drawn.

Latter parts of the questionnaire employed closed questions using a 5-point Likert rating scale (strongly agree to strongly disagree) that provided some numerical data. These data were graphed as histograms, and means, standard deviations and modes were calculated where appropriate. The data were then further interrogated by looking for differences between the means of a number of variables, difference significance being examined using the Chi Square test for more than two independent sample distributions (Moore & McCabe, 1999; Wiersma, 1986). Difference significance was also examined using differences in percentage of agreement, this being defined as the combination of the strongly agree and agree ratings on the Likert scales.

The results of the graduate survey are discussed in Chapter 5. They laid the foundation for the interview questions used in the subsequent phase of the research, the longitudinal study.

4.7.2 The longitudinal study design

Determining the sample size and selection procedure is a key part of any investigative research, and this is one area in which qualitative and quantitative inquiries differ significantly. Quantitative research looks to a sample size that can provide data that can be regarded as statistically significant. "Qualitative inquiry typically focuses in depth on relatively small samples, even single cases, selected *purposefully"* [original italics] (Patton, 1990, p.169). Purposeful sampling selects information-rich cases, which can reveal information about the issues at the core of the purpose of the research (Patton, 1990).

In this study the population of all second year BSc(Tech) students who would be undertaking work placements over the next two years of their degrees would provide a sample of students. Participation was invited by way of an open invitation through lectures with a request for volunteers. Admission to the project was subject to the student gaining a placement at the end of their second year of study. A further consideration was that they had gained a placement within two hours drive of Hamilton, for the pragmatic reason of being able to reach the student for interviews in the workplace. The group of volunteers was later augmented by direct invitation to selected individuals who had secured placements, in such a way that a balance was attempted across gender, across subject majors (except biology) in proportion to the total population, and across a range of employment sectors. This sampling method has been termed stratified purposeful sampling by Patton (1990) and quota sampling by Cohen et al., (2000). Assurances were given to prospective participants prior to their commitment of their rights and all ethical considerations (see Section 4.7).

A group of 22 students agreed to participate in the study, 12 males and 10 females. Information about the participants is documented in Appendix A. This group size allowed for a balanced sample as described above and for sample mortality over the period of data collection, being approximately two years.

Each participant was interviewed individually on at least four occasions as specified below in Table 4.1.

Table 4.1. Schedule of Interviews

Interview 1	Before beginning first placement, at end of second year of study
Interview 2	Towards the end of the first placement in the workplace (placement duration 3 months)
Interview 3	After first placement, and before second placement, while in third year of study
Interview 4	During second and final placement in the workplace (placement duration ranged from 3-9 months)

As described earlier the interviews were semi-structured, and the questions were based on the findings of the graduate survey. In broad terms they investigated the learning experiences of the students in their science and technology workplaces, and the integration of these experiences with their learning at university.

An interview guide containing a set of questions was used for each interview (Kvale, 1996). The set of questions were placed in an order, but in all interviews that order was not strictly followed, as the interviewee would often talk about issues 'out of order' and this was encouraged to allow freedom of expression. Nor would all questions on the interview guide be asked of the interviewee, and judgement was employed on my part as to which questions would be appropriate in each situation. Prior to undertaking the first interview of each set the general interview guide was piloted with one or two appropriate non-participants to check for question sense and validity. Each interview guide was then tailored slightly to the individual participant and later-interview guides included follow-up questions on issues raised in early interviews with the same individual. Examples of the general interview guides are documented in Appendix C.

After the first set of interviews in the workplace (Interview 2) I became concerned that by conducting just one interview towards the end of the first placement, I was only tapping into what elements students could remember over the preceding 3 months. I felt I needed more regular data to chart learning changes more closely. So five students (Joe, Jill, Kara, Kathy and Vanessa) were invited to have more regular interviewing during their second work placement. These students were interviewed 4-5 times during this placement. Typically the schedule would involve an interview very early in the placement, one or more soon after, and one at the end of the placement. These students developed into case studies, in which

more in-depth exploration of their learning experiences could be undertaken. Case studies from two of these students, Joe, and Jill, are presented in Chapter 9.

All interviews were audio-taped, and some field notes were taken, but these were kept to a minimum in order to allow a more conversational mode to be gained in the interviews. Notes were taken immediately after the interview about the progress of the interview, any influences on the interviewee from the environment, and their non-verbal communication (Patton, 1990). The tapes were transcribed verbatim as soon as possible after the interview (Patton, 1990) and the transcript checked against the tape-recording for accuracy. The participants were then given the opportunity to check and comment on the accuracy of the transcripts. Once checked, further information not contained in the actual text, for example tone of voice, emotion, or long pauses, was added to the transcript as notes at this point for use in analysis (Cohen et al., 2000).

In reporting the interview data in this thesis, pseudonyms have been used for all participants. Data presented has been assigned a code which comprises the first two letters of their name, the number of the interview and the page number on the transcript from which that data has been taken (see Appendix A).

In addition to gathering data through interviewing, some triangulation was achieved through students writing journals about their learning experiences. There was no compulsion to write in their journals and the use of learning journals is not a regular part of the placement programme. Students were asked to submit their journals to me after each placement. Some students used their journals extensively in their first placement and some of their data appear in this thesis, while other students used theirs little or not at all. Few students continued with their use in their second placement.

4.8 Chapter summary

To answer the research questions posed in this study an interpretive methodology was adopted. This methodology would permit examination of learning outcomes and process through expression of the students' meaning of their experiences on

their work placements. This methodology also sat well with the notion of socio-cultural learning, based as it is on participants' experiences of the social and cultural environments in which they are placed.

A longitudinal study was chosen as it allowed for an examination of both student learning outcomes, and process, and would contribute to an understanding of any transition that a student undergoes between the world of student and the world of science and technology practitioner. Data collection was principally by semi-structured or guided interview. Categories of analysis emerged from the interview framework and were situated within cases built around each participant. Within-case analysis reduced the data and provided contextualised experiences for each student, and cross-case analysis looked for similar meanings and experiences between students.

The trustworthiness of the study was enhanced by the use of multiple interviews over time, triangulation with alternative data sources, negative case analysis and member checks on the data. Where appropriate thick description of the context of the research has been provided, as well as clear description of how the research was conducted. I have acknowledged my own background and position with respect to the research and the participants, so that my influence on the research can be judged. Care has been taken to follow ethical procedures at all times.

The interview guides were informed by my own experience in working in cooperative education, and by a survey of BSc(Tech) graduates about their retrospective views of their learning through their work placements. The next chapter presents results of that survey.

Chapter 5 Results and Discussion

A graduate survey

5.1 Chapter outline

As discussed earlier (see Section 4.7.1) the graduate survey formed the first stage of data collection. The purpose was to gather retrospective views on learning in work placements from graduates of the BSc(Tech) programme. There was plenty of anecdotal evidence and ideas about student learning in the work placements from my experience as a co-operative education practitioner, but these ideas needed to be clarified in order to form a framework for the longitudinal study. It was important to consider if there were any significant differences in learning when considering differences in placements such as length of placement, placement company business and its size. If evidence for such differences were found, it would be necessary to consider the impact of these differences on the experiences of the students that were to be studied across a wide range of workplaces in the longitudinal study.

This chapter describes the survey responses and summarises the key findings. It concludes by describing a number of guidelines that were used in the longitudinal study for further investigation of student learning on work placements.

5.2 The Survey Responses

The survey employed questionnaires which were mailed to each graduate's last known address. Of the 125 questionnaires sent out, 95 were returned for a response rate of 77%, 77 (62%) being returned in the first instance, and the remainder after a follow up letter.

The sample of 125 graduates had completed their last placement between 1989 - 1997, being 29% of the BSc(Tech) graduate population over that period. Total response (95 graduates) was 22% of the population. Of respondents, 81% had completed their last placement in the last three years (Table 5.1).

Table 5.1. Year of Respondent's Completion of the Work Placement

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Number of respondents	1	0	0	6	5	4	22	28	27

Respondents were spread in their subject majors in proportion to the population of BSc(Tech) students who have graduated over the same period (Table 5.2).

Table 5.2. Subject Majors of the Respondents

	Biology	Chemistry	Earth Science	Physics/ Electronics	Computer Science	Forestry
Number of respondents	41	18	25	5	3	3

The design of the questionnaire and its content were described in Section 4.7.1. Briefly, the questionnaire asked open questions about students' perceptions of their learning, combined with closed questions on some specific areas of learning such as technical knowledge and skills, relationships and work culture. The questionnaire can be viewed in Appendix B.

The graduates had undertaken a variety of placements in a wide range of organisations and under varying circumstances. In an effort to understand how learning may vary with the varying nature of placements, four placement characteristics were examined for differences with graduates' reported learning within their placements. These were:

- length of placement. Graduates were asked whether their placement was short (< 4 months), medium (5 - 9 months), or long (> 9 months)(placement duration in the BSc(Tech) programme is typically either 3 or 9 months but some continue for up to 12 months). As graduates were asked to only consider their final placement, most (52%) were in the medium range as this is the typical length of the final placement in the BSc(Tech) programme. This

placement characteristic was considered in order to examine if the length of time in the workplace had a bearing on learning.

- the nature of the employing organisation's business. Students in the programme tend to be placed in either research, manufacturing or local government organisations and it was of interest to determine if there might be any link between learning and the employing organisation's business focus. Anecdotal evidence suggested that students working in a research environment perceived that they learnt more than those working in a routine manufacturing environment. Whilst each graduate's reporting of their organisation's business was subject to the graduate's interpretation of that business, 99% (94/95) of graduates reported their placement organisation's business in a way that matched the researcher's view of their organisation. This question sought to understand the overall nature of the organisation's business and hence its culture, and recognises that the graduate's work may have varied in type even within the one organisation.

- the employing organisation's size in terms of staff numbers. Broad categories of size were given as small (1-10 staff), small/medium (11-50), medium/large (51-500), large (>500). This reporting was open to the graduate's interpretation of the actual size of the organisation, being dependent on whether they reported on the organisation at the local level, the national and in some cases the international level. As such results of this influence should be treated cautiously. This question sought to investigate if learning was influenced by the size of the organisation that the student was placed in.

- the number of daily contacts with workplace colleagues that the graduate had on placement. This was an attempt to determine if working with different numbers of people had an effect on learning. This factor was also open to the graduate's interpretation of what constituted contact and this limitation was recognised in analysis of the data. Options given were: 1-2 people, 3-5 people, 6-10 people, >10 people.

The following analysis reports on the graduates' perceptions of their learning and is followed by a discussion of the implications for the longitudinal study. Data discussed can be viewed in raw form in Appendix D.

5.3 Survey outcomes

5.3.1 Graduate perceptions of what they learnt in the work placement.

86% of graduates rated work specific skills such as technical skills and theoretical knowledge as the most significant learning they gained, but also reported learning (58% of graduates) in an array of areas often described as soft or general skills, such as communication and time management skills. Included amongst these general skills were those that could readily be transferred to other workplaces, such as problem solving (10%) and report writing (21%). Personal development (42%) and an understanding of their company, their industry and their career (40%) were also mentioned, but by fewer graduates. The very fact that these learning outcomes are less tangible could lead graduates to put less credence on these areas, or it may simply have been harder for them to determine, or indeed harder to remember, if learning had occurred within these elements.

It is interesting that learning of technical skills is identified as a key outcome in the work placement. The science and technology students within the BSc(Tech) programme are very often employed in a technical role, and this opportunity may allow development of skills that cannot easily be accomplished in university-based laboratory classes of limited duration, scope, and availability of the latest technical equipment in large classes.

When asked specifically about technical skills, 99% of the graduates acknowledged their technical skill development in the placement, indicating the important role this learning has for the student on placement. This role appears to be unaffected by the length of placement (there was little difference in reporting of technical skills learnt across the different placement length categories) and it would be reasonable to assume that important technical skills are taught early in the placement so that students can become productive as soon as possible.

The learning of technical skills was also unaffected by the company's business focus, be it research, commercial or local body work (again there was little difference in reporting that technical skills were learnt across the different nature of business categories). Using the Chi square test for more than two independent sample distributions, no significant differences ($p<0.05$) were found in students' reported learning in the different businesses. This could be a reflection of the fact that the nature of positions held by students on placement within each of these sectors is largely technical, or a difficulty of exploring these differences using the survey method.

More graduates acknowledged the learning of theory in research environments (96%) than in commercial (86%) or local body environments (76%). While these differences are not great, they may indicate a difference in access to knowledge within the different communities of practice. For example, it is possible that within the research institution students are more encouraged to participate in the joint construction of new knowledge through being given access to scaffolds in the form of discussions and relevant literature. In commercial environments, more emphasis may be on production of saleable items and less time may be given to students to participate in knowledge construction. This interpretation of the preliminary data merited further investigation in the longitudinal study.

Approximately half of the graduates (42%) stated that they were able to apply theory learnt at university to the workplace. This is a rather disappointing figure, considering that application of theory is widely quoted in the rhetoric used to support co-op programmes. Given this finding, it was important that this perception amongst the students was further investigated in the longitudinal study, where more in-depth questioning through the use of interviews held the potential to explore this further.

Graduates also reported that learning occurred about workplace language (94%) and relationships (92%), and to a lesser extent about how things were done in science and technology (84%) in their placement organisation. Many graduates identified their learning of workplace language (72%) and relationships (64%) as

being influential in helping them to feel more a part of the company they were working in. Some graduates (7%) also highlighted that the importance of knowing who key people were in their organisation was something that could have been better covered in their induction to their placement company. These facets of working life could be viewed as not directly contributing to productivity and yet have been identified here as very important in the process of developing a sense of belonging within the students on placement. These data provide some indicative evidence that social and cultural factors are important in the learning that a student can achieve in a work placement, and point to potential for further investigation of these factors in the longitudinal study.

5.3.2 Graduate perceptions of how they learnt in the work placement.

In response to an open question about how they learnt, 52% of graduates perceived that learning occurred through the practice of undertaking work activities. This implies that students on placement perceived that they learnt by carrying out their work. The opportunity for doing tasks themselves brings the students into contact with the 'tools of the trade', and they experience participation in the cultural activities of their work place. The longitudinal study could investigate whether this led to participatory appropriation (Rogoff, 1995) over time, mediated by those tools of the trade (Wertsch et al., 1995). Further learning processes reported by the graduates included interaction with staff such as being shown what to do (34% of grads), discussion (25%), being given instructions (20%) and asking questions (21%). This points to the importance of the workplace staff in the learning process.

Discussions with work supervisors were perceived to have helped learning by 58% of graduates in the survey, and it is possible that supervisors assume the role of a mentor. Ricks and Van Gyn (1997) undertook a study of mentoring of students in co-op programmes in Canada and reported a clear indication that students in the programmes valued a mentoring relationship that was "relational and transformational", in which the relationship is "two-way, is more deeply personal..... and affects the protege's life in a significant way" (p. 51). The

longitudinal study offers the opportunity to provide some data on the development of mentoring-type relationships during the students' placements.

Being shown what to do by workmates was reported to help learning by 68% of graduates in the survey. This may relate to the position of workmates as people regularly working alongside the student and teaching the details of the work tasks to be undertaken. This contrast to the learning by discussion with supervisors on placement indicates differences in the ways that students may become enculturated into the workplace community, which could be further explored in the longitudinal study.

When graduates were asked their perceptions of how they learnt theoretical knowledge in their placement (see Question C1.e in Appendix B), talk with work supervisors and workmates was reported as a process for learning knowledge by 86% and 84% of graduates respectively in this survey. When asked about how work supervisors helped them learn, graduates in this survey noted that their supervisors provided background information to help them understand the scope of their work. Graduates reported that their work supervisors and workmates in their placement were influential with learning workplace language (81% and 84% respectively), and technical skills (84% and 84% respectively) (see Q C2.d and Q C4.d in App. B), although data from an open question about how supervisors and workmates helped learning suggested that workmates were more important in learning technical skills. This latter data may be more consistent with the workmates' daily contact with the student and their possible role in students' learning the details of the business at hand. Graduates reported that observation was a key process in their learning about workplace rules (64% of graduates) and relationships (86%), in particular the latter. Graduates noted that reading published papers (38% of graduates) and company literature (48%) were only important in the learning of theoretical knowledge in the workplace.

There were no significant differences ($p<0.05$) found, using the Chi Square test for more than two independent sample distributions, between how learning occurred and the length of placement, the nature of the employing organisation's business or its size.

Information on how learning occurred is not easily obtained through the questionnaire method, as there are many potential variations in how graduates may have interpreted and reported these learning processes. A certain amount of interpretation of the data by the researcher has been necessary. Nevertheless the data has provided indications that students may learn in a variety of ways in their placements that indicate the importance of social interactions with their supervisors and workmates, and enculturation into the practices of their communities of practice at work through the use of tools and artefacts. The interview method for the longitudinal study could provide better data on this question.

5.3.3 Graduate perceptions of who they learnt from in the placement.

The graduates in this survey indicated that work supervisors (86%) and workmates (80%) were the most important contributors to their learning in their placement. They perceived that learning occurred through social interactions (with work supervisors (86%) and workmates (80%)) and through observations (of work supervisors (12%) and workmates (23%)). These data also point to the social nature of the workplace and how knowledge and information is passed on through person-person interactions. It also contributed to the possibility of a cultural difference in the workplace in the way that a student may interact with a supervisor and with a workmate, and in the type of information that supervisors and workmates might provide. This difference would merit further investigation in the longitudinal study.

An aspect of concern arising from this study was the lack of support accorded by the graduates (27%) to the contribution of the academic supervisor and the placement co-ordinator to learning in the placement. The role of the academic supervisor in the programme is to assist with interpretation of theoretical and technical details and with the writing of the placement report, and then to assess that report. It could be argued that these are minor roles in the context of the whole placement, and this may well be the perception of the students. Nevertheless it is somewhat disturbing to think that the students perceived that they learn so little from an academic supervisor whose prime business is

education. Dawson (1980-81) argued coherently for the key role of an academic supervisor in helping a student on placement to expand their expectations for learning. The role of the placement co-ordinator in the BSc(Tech) programme is to facilitate finding a placement for the student, to monitor learning and welfare of the student in the placement and assist in assessment. As such the co-ordinator also has a subsidiary role in the student's learning, but this data suggests there is an opportunity to improve that role. In recent years co-ordinators in the programme have been placing increasing emphasis on student learning during their visits to the students in the work placement, and this data suggests that trend should continue. The graduate survey data indicated that it would be important to explore the significance of the roles of the academic supervisor and placement coordinator in student learning on placement in the longitudinal study.

Differences were looked for between the contribution to learning of those people involved in the placement and the nature of the employing organisation's business, and its size, and no significant difference ($p<0.05$) using the Chi Square test mentioned above were found. Such differences may be more easily probed through the interview method within the longitudinal study.

5.3.4 Assessment of work placements

Assessment is a part of learning, and is formally practised within an institutional setting, so it was interesting to investigate the graduates' perceptions of assessment of the work placement. Assessment in the BSc(Tech) programme placements is carried out through visits to the student while they are in the workplace, an assessment of the student's work performance by their work supervisor, and a report written by the student on their work which is assessed by the university supervisor.

Overall the graduates (63%) supported the notion of assessment of placements but felt there was a need to refine the methods of assessment to better incorporate all aspects of learning in the work place. The graduates were asked if and why they felt it was important that their placement was assessed at all. Some written comments from the questionnaire responses were (quote codes refer to

G=graduate, then the number assigned to the respondent from whose questionnaire the data is drawn):

> Allows a summation of the year as a whole learning curve - if only in my head during report writing. Helps reflection on achievement. Lets employer see they are gaining from allowing student placements. (G15)

> I think the assessment cements what you have learnt in your mind. If this was missing you wouldn't remember nearly as much, so I think that assessment is an integral part of the learning process. (G95)

These comments gave an indication of the students' perception of the significance of assessment, and pointed to the importance of reflection on the experience. Some graduates in this survey (5%) specifically mentioned the writing of their placement report as a tool for reflection. It would be important to investigate the use of reflective processes such as reflection-in-action (Schon, 1983) by students in their placements through the longitudinal study.

Most graduates (81%) asserted that the assessment for their placement had given them an opportunity to demonstrate their learning. Some written comments were:

> Yes as far as theoretical knowledge and technical skills are concerned. Most important learning was the transition from the Uni mindset to workplace e.g. freedom in the workplace lab - this was not readily demonstrable in the report. (G23)

> It is good that we have to write about what we have learnt besides theoretical knowledge (e.g. communication skills) as I feel I learn more about those things (confidence in the workplace). (G40)

The graduates' comments pointed to social and environmental influences in the workplace which they felt were different to those they had experienced at the university. The notion of the change in mindset points to a cultural movement in ways of thinking, and that the learning may involve enculturation into a new sociocultural setting (Brown et al., 1989; Lave, 1991). Exactly what had brought that about and who contributed to that change could be explored in the longitudinal study. It would also permit further investigation of student learning of

general skills such as communication skills that 12% of graduates felt were not properly assessed in their placements.

5.4 Chapter summary

The graduates' survey responses provided three key findings, affirming the anecdotal evidence that I had previously gained during my work as a co-op practitioner:

- Graduates perceived that they undertook learning in the work placement about a range of knowledges and skills.
- Graduates perceived that they learnt in different ways in the work placement.
- Work supervisors and workmates are perceived to be important to students' learning.

These graduate data provided a direction for the ensuing longitudinal study and were instrumental in the framing of zones of enquiry for the interviewing of a new cohort of students as they passed through the work placement programme. The survey provided a foundation to the argument that learning occurs in work placements, and provided student-derived indications that investigating student learning in their co-op placements from a sociocultural perspective may be fruitful.

The survey data provided the following guidelines that framed the interview enquiry. They were to explore:

- How the sociocultural setting of their workplace shapes what a student perceives they learn on placement.
- A student's perception of what they learn over time in the placement.
- A student's perception of how they learn on placement.
- A student's perception of the social process of their learning, and whether that differs between types of workplaces.

- A student's perception of how workplace relationships develop in the placement, in particular with the work supervisor and the workmates, and how learning flows from this development. Do students develop mentoring-type relationships with people at work?
- A student's perception of the application of learning between the university and the workplace settings, and how learning in each setting may differ.
- A student's perception of learning to work in science and technology.
- A student's perception of the role of the academic supervisor and the placement co-ordinator in providing learning assistance to the students.
- A student's perception of how assessment procedures reflect their learning in the placement.

There was a high response rate (77%) to the survey questionnaire. This high response rate is perhaps on the one hand indicative of the commitment that the graduates have to the programme, and perhaps also indicative of a strong interest on behalf of the graduates about their learning and how the placement impacted upon it. The survey's limitations rest on the relatively small sample size and the difficulty of eliciting clear responses to certain questions through the medium of a questionnaire. Many of the questions were open to multiple interpretations, which on the one hand provided a richly diverse set of data, but on the other hand produced little explanation of the data. In some cases similar questions asked in an open way and a closed way elicited quite different data, indicating the fallibility of the method in obtaining consistent and accurate information. A further limitation was its retrospective nature, relying as it did on the graduates' recall of events that, in some cases, happened several years ago, and that have since been tainted by subsequent experiences. A final limitation was that the questionnaire requested a summary of learning from the graduate that may not have elicited sufficient details about the process of learning that the graduate would have undergone during the placement. The use of interviews as the vehicle for data collection in the longitudinal study allowed for many of these limitations to be overcome and for many of the issues raised in the graduate survey to be further explored.

The guidelines above informed the collection of data in the longitudinal study which followed a cohort of 22 co-op students through their BSc(Tech) programmes. The following chapters discuss the data from that study.

Chapter 6 Results and Discussion

Sociocultural views of learning in the work placement

6.1 Chapter outline

The data presented and discussed in Chapters 6 to 9 is drawn from the interviews and journal writings of the 22 students who participated in the longitudinal study. This first Chapter discusses the student perceptions of learning in their work placements that could be interpreted from a sociocultural perspective. It begins with a look at the experiences of the students as they entered the new sociocultural setting of the workplace. This is followed by discussion of firstly examples of learning viewed as socially mediated, situated and participatory activity, and secondly examples of learning as mediated action, as reported by students from their work placement experiences. Student data is presented using pseudonyms and is coded according to their surname/the number of interview/the page of transcript, or in the case of journal entries their surname/journal page number. For background on the participants, their pseudonyms and codes, see Appendix A.

6.2 Learning about the sociocultural setting of the workplace

This study explored what and how students learnt through undertaking work placements in a co-op degree programme. These placements situated the students in a setting distinct to that of the classroom; that of the workplace. For some students in this study their work placement was their first time in employment, outside the family business; for others it was their first time employed on a full-time basis; and for yet others who had previously experienced full-time employment, it was their first time working in an area of science and technology related to their career interest. In this study it was important to consider this range of previous work experience to determine if student learning was influenced by this prior experience, an effect that has previously been commented on by co-op researchers (Van Gyn et al., 1996) as having potential to affect student learning on placement.

This section then begins by examining the students' previous work experiences. This is followed by a discussion of how a variance in previous work experience affects learning about work ethics. Later sections describe student learning about adjusting to the routine of work, and what two students learnt about some of the workplace's more undesirable characteristics.

6.2.1 Students' previous work experience

As noted above, students in this study had a range of previous employment backgrounds which may have influenced their learning in their work placements. This section outlines the employment backgrounds that the students had prior to this study. (Where appropriate, these experiences are acknowledged in later sections when discussing students' learning).

In the current tertiary environment in New Zealand many students work in part-time and vacation jobs in order to finance their university study. All of the students in this study had done this sort of work prior to entering the programme. Indeed many students continued with part-time work during the teaching semesters. The work undertaken was predominantly in retail and service industries, and was either in family businesses or private companies. This work was described by the students as non-career orientated and simply a means to earn money.

Of the 22 students in the study 18 had come to university straight after finishing secondary school. These students were aged between 17 and 18 when they entered the programme and had not worked full-time for longer than the three-month summer vacation between school years. None had worked in a job related to their studies, although one, who was studying forestry, had worked in her parents' plant nursery.

The remaining four students were aged between 20 and 24 when they entered the programme and had differing employment histories. For example, Christine had worked in a number of positions: as a vet's assistant, a medical diagnostic technician and as a deckhand on an ocean-going tug. She came to university

because she realised that she had got as far as she could go in the sort of work she was able to get, and she wanted "to see if I could improve myself at university" (Ha/1/2). Karl had worked in a variety of industrial positions, and had been working in an industrial manufacturing plant as a quality control officer immediately before coming to university. He came to university because his supervisor at his last job had told him he should, so that he could get a qualification in order to progress his career. James worked for four years as a science technician at a research institute before getting frustrated with his lack of progress up the career ladder. He came to university to study in a different area of science. Kara had worked for a year in a supermarket, while she decided what she wanted to study and saved some money.

With this variety of working backgrounds, the students in this study reported different perspectives on learning about the nature of the work environment. This was evident in the learning about the development of a work ethic.

6.2.2 Learning about a work ethic

A work ethic can be defined as the ways of working determined by the norms of behaviour in a certain workplace (Levine & Moreland, 1991). The work ethic is then a behavioural element associated with the workplace, and the ethic itself is a trait that is informed by social interactions at work, in which the newcomer models their working behaviour on the attitudes and values of their workmates. Each workplace may have different work ethics, as ways of working may vary between types of workplaces.

Two different views concerning the development of a work ethic were expressed by the students, the difference occurring with students who had experienced differing amounts of previous work. The first view was espoused by students who had little previous work experience, typified by Rick. Rick's previous work experience amounted to a few months of apple picking, and he had not had a part-time job while studying at university, commenting that "university is a full-time job" (Pa/1/13) and that it didn't work for him trying to do both study and part-time work at the same time. For him learning a work ethic was significant in his

placement as he said: "Personally I think you learn the whole work ethic thing, just to sit down and do something" (Pa/3/7). Rick was highly respectful of the organisation in which he undertook the placement about which this statement was made. He reported his observations of the organisation in which people worked hard and honestly, and awards recognising the organisation's successes were prominently displayed. He commented: "The [company] has a good name throughout the world and throughout New Zealand, and everyone gives the impression of doing very hard work" (Pa/2/4). This role modelling by his workmates and the display of icons of the organisation appears to have influenced Rick's perceptions of what it meant to work in that organisation. The opportunity to observe and be a part of that environment at work had influenced Rick's learning about a work ethic.

A different view about learning a work ethic was expressed by students who had previously worked fulltime for longer than summer vacations, or who had a lot of part-time work experience. For example, Christine, who had worked for several years before coming to university, felt that learning about a work ethic on placement applied to those students who hadn't worked much, but she saw it as unimportant for herself:

> I have got a different perception about [learning about a work ethic on placement] than people younger than me because they never have worked so they don't know what it is like, what is expected of them and things like that (Ha/1/10).

It was Christine's impression that her previous work experience had developed in her a work ethic and that further experience of a work environment would add nothing new to her learning about the nature of work. She cited evidence to back up this claim in the very favourable reaction of her work supervisor to her diligence and organisational skills. She described an incident in her second placement:

> Yeah it was probably the first day I packed the [vehicle] before we drove up to Auckland, and [my work supervisor] had a look in and congratulated me on my tidy packing and I just said 'oh, I worked for a boss for eighteen months whose motto was there's a place for

> everything, and everything in its place', and I said, 'you know, when you're working on a boat and you go out to sea and there's a forty knot wind, you know, things have to be packed away, otherwise they'll break and you're in trouble'. You know it's just ... I hated it when I was doing it, you know, on the boat I probably resented being told to put the stuff away all the time, but now I'm thankful because it's given me a good kind of work ethics and things (Ha/2/6).

Based on their previous work experience, James and Martin expressed similar perceptions about work ethics. James, who had worked for four years prior to university noted the ease with which he made the transition back into the workplace in his first placement, "it is more of the same, I worked for four years before I was at University, so I just slotted into the same old way I used to be" (Sk/2/13). And Martin, who had worked at part-time jobs since he was 15 years old, commented that going to work was not "an issue" for him.

This study has shown that the students with little prior work experience learnt about work ethics through undertaking a work placement. The students learnt work ethics through observation of their workmates and the sociocultural setting of the workplace. In addition this study has shown that the students with multiple and/or prolonged previous work experiences learnt little through their placements about work ethics, reporting that they had learnt how to work prior to undertaking their placements.

The amount of previous work experience was not always a factor in how students experienced their entry into the novel environment of a new workplace. These experiences are discussed in the next section.

6.2.3 Experiencing a novel sociocultural setting at work

Although all the students in this study had worked before in at least a part-time capacity or over a summer vacation, some had only worked on their family orchard or plant nursery, and many had worked only in small organisations. In addition for the first time all of these students were going into organisations to do work that was related to their career interests and their studies. Students found this

entry into a new sociocultural setting of the work placement to be stressful. The stresses included meeting new people and being apprehensive about the work they would be asked to do.

For example, Vanessa found meeting everyone on her first day at work exhausting:

> A bit scary, because you get introduced to a whole lot of people, and just a new environment, and everyone is looking you up and down, at the new student, just a lot of information to absorb at once. I got home and I was absolutely stuffed (Sto/2/6).

For Vanessa the intensity of exposure to a new range of social interactions and the scrutiny of the new person-on-the-block proved very tiring. Other students experienced nerves before starting their first placement, having doubts about their ability to perform up to expectations, an issue discussed by Levine and Moreland (1991), and whether they would get on well with their work supervisors. Kara was typical of this group stating that she felt very nervous on her first day because she didn't know if she would be able to do what was asked of her, and that she "was scared of looking 'dumb' [her emphasis] in front of everyone" (De/J1). Rick also wondered aloud whether he would be "actually qualified to do this" (Pa/1/14) before his first placement. And before her second placement Lucy was worried because her job was going to involve using a particular technique, which she had only carried out once at university and "I stuffed that one completely". She commented that "What if [my supervisor] looks at my results and goes 'What the hell did you do'!" (Str/3/10).

However, in Martin's situation, he had had plenty of work experience, had even commented earlier that going to work was not an issue for him, and had already completed one work placement. Yet at the beginning of his second placement he was nervous because he perceived that he didn't understand the work environment he was going into:

> I felt nervous because I ... the job that I had as a researcher was not exactly what I intend to do as a job, so that was probably the

> most nervous ... I was thinking I've never done this sort of work (Ri/4/8).

In this case the student, Martin, was nervous about the expectations the organisation would have of him as a researcher, as he had "never done this sort of work". Although Martin had experience of a number of different work environments, the research environment was unknown to him and therefore was a source of unease at entry. Despite being an 'experienced worker', Martin felt ill-equipped to work as a researcher.

Other students had concerns about getting on with their work supervisors and their workmates at the start of their placements. Christine showed she was concerned at how she might get on with her work supervisor when she remarked "...on the first day I was just nervous because I was trying to get on with [my supervisor] and I didn't really know him" (Ha/2/7). Christine's concern showed how important the social relationships at work were to her and this concern was echoed by many of the other students. Prior to their placements they were anxious about what the people at work would be like, whether they would be friendly and helpful or expect too much of them. In all cases, students reported overcoming these concerns within a few days of beginning the placement.

The concerns expressed by the students were indicative of their lack of knowledge of, and feelings about, what takes place in the workplace. The opportunity that the students had to experience a new sociocultural setting in their work placement was reported, however, to contribute to their sense-making (Louis, 1980) about this new setting, and to contribute significantly to their personal development, which is discussed in the next section.

6.2.4 Personal development in the workplace

Students reported development in their self-confidence, time management and interpersonal skills in their placements. While the development of these personal skills is grounded in the particular workplace, these types of general skills are often viewed as transferable to other workplaces and settings.

In total, 4 out of 22 students spoke specifically about their increase in confidence through their work placements. It is likely that this figure is an under-representation of the increase in confidence in students during their work placements, as most students reported that they felt less nervous about starting their second placement than they did their first, because they knew more what to expect, and also that they felt more comfortable in the workplace the longer they were there. One of these students was Kara, who commented after her second placement:

> I gained a lot of self confidence in working by myself because I never really had that before, I mean even with doing work and then labs [at university], I always had to be with someone to help me understand what I had to do. So in that sense I've really learnt to work unsupervised and by myself (De/4.4/5).

In her second placement Kara was working on a project individually. She had little supervision and only the support of a fellow student. She commented that the placement forced her to take responsibility for her own work and she learnt that she could do it without too much direction. Whilst the placement situation with little supervision and support would not normally be viewed as desirable for encouraging learning, it did provide an unexpected learning opportunity for Kara. She explained how the confidence that she had gained in her placement helped her apply for, and get, a job at the end of her degree.

Another personal skill reported as learning by some of the students (4/22) was time management. These students typically were given a number of tasks to do on a daily or weekly basis, and they had to arrange their own time to complete them all. Vanessa experienced this is in her second research placement:

> I think what I have learnt more is how to organise my time better and try to focus on one thing and get it done and move on to the next, and [my work supervisor] is a big one for writing out lists, and then we prioritise what I should be doing, and that helps me, and that's been a good habit to learn (Sto/4.2/6).

Working with her supervisor at work had exposed Vanessa to list-making, which she in turn adopted as an approach to managing her time. Vanessa was given responsibility for running experiments and collecting data, and she learnt how to manage the resources she needed, both equipment and people.

Interpersonal skills were another skill area mentioned in their learning by a number of students (13/22) in this study. The workplace is a sociocultural setting in which most people work with others, and this usually involves the use and development of interpersonal skills. These include how to communicate with workmates and others in the workplace, and how to work and interact with them in a team environment. For example, in his second placement Craig was working in a small company getting a new business off the ground. He commented that "I learned about people a lot, quite a lot about different people and their different attitudes and how to work and interact with other people, how they behave quite differently in a team" (Su/3/4).

Craig saw it as very important that you are able to relate to your workmates for a harmonious workplace, citing the example of one workmate who could be very disruptive at work because of his behaviour, and another of a colleague who wasn't allowed to work directly with customers because he lacked good interpersonal skills. In another example relating to workmates, Nancy felt that it was important to be in "touch with whether they are OK emotionally, because that can affect their work" (Wo/2/20).

These skills, self-confidence, time management and interpersonal, are learnt within the context of work but could be readily applied to other situations. By entering a workplace, the students have had opportunities to discover their own abilities, develop new work habits and understand how people can work together. These skills may not be developed exclusively in a work placement but are likely to be developed in a different way to that which may occur in a university setting. The next section explores how students learnt about how routines of practice may differ between the workplace and university communities.

6.2.5 Learning about the difference between the work and the university routines

Students in this study reported learning to adjust to a routine at work (Levine & Moreland, 1991) that was different to that which they had been used to at university. The difference revolved around the use of time and the organisation of the day. While at university, the students were responsible for organising their own time, although the timetable of classes did provide some constraints. The students found however that they could get free time between lectures and laboratory classes, and even during those classes for the less diligent. However, once at work, the need to be at work for an eight-hour day was hard for some. Duncan made this observation:

> Yeah it's different to what I thought. I found it real tiring for the first while. Like when I was at uni. I thought a job would be awesome, because I would have the nights free, no homework. But at the end of the day at work, I'm pretty stuffed (Ho/2/9).

Duncan found that although once he left work his time was his own, free from studying, he was in fact so physically tired from the work that he had little energy to do other things. Donna found that she was also mistaken about what working would be like as she compared it to being at university: "Not as cool as I thought it was. Being a student actually is not so bad" (Ni/2/9). She felt the pressure of having to perform from eight until five, and missed the university lifestyle where you could sleep in if you felt like it or doze off in a lecture (Ni/2/10). She too found this new environment tiring.

In Lucy's case it was the physical lack of time after work due to her hours of work that she commented on:

> Well I know more of what is expected of you in a work environment ... it goes to having no time to yourself. I mean when you're at varsity, it's like go to a couple of lectures, then go home and 'oh I've got all this spare time', and this is like eight to five, get home at six, have dinner, do the dishes, you've got an hour maybe, and then go to bed and do the whole thing again the next day (Str/4/11).

In discovering the daily routine of work, Lucy reported learning that the working lifestyle afforded her less freedom to do what she wanted to do. Nancy expressed her perception of discovering the reality of the working lifestyle in a different way, when she commented after two months in her first placement that "it feels like work. It feels like the real thing. It's a different feeling to 'hey this is new, this is different'. It's regular work now, it's lost its charm" (Wo/2/10). Nancy's emphasis was one of acceptance rather than resignation, having reached an understanding of what work was about. Her work was largely of a routine nature at the time she made this comment and the lack of challenge and stimulation that her work was giving her may have contributed to her feelings.

Another effect of moving into a working environment for some students was the loss of the long summer holidays and semester breaks. Victor commented that "I don't get the holidays I'd like. Throughout secondary school and university you get three or four months a year off, and you just don't get that in the real world. It's very disappointing" (Ro/4/9). Although this statement was made with a wry smile, it was a sentiment echoed by other students, who found it hard that their friends were off on holiday at the beach whilst they were working. Victor, however, was content with his situation, having been offered an extension of his contract during his second placement, with a good chance of a permanent position. He felt that he was now "into the groove of the real world" (Ro/4/9) and used to the working lifestyle.

On the plus side of working when compared with the university environment for some students was the chance to go home at the end of the day and not have assignments hanging over your head. Rick noted:

> It's actually a lot more relaxed than university work because the thing about it is you start it and want to finish it by 5 o'clock, and then you go home and don't have to do assignments then, extra things. You've finished it basically (Pa/2/8).

Mike felt the same way:

> You don't have to take it home with you, like, for instance when you're at university there always seems to be something sort of hanging over your head that you've got to do, got to hand in, but like when you work in the type of work that I'm doing, hey you can go home and just forget about it and come back the next morning, which is good (Mc/2/11).

For these students the working lifestyle meant that work ended when they went home at the end of the day. The students in this study normally entered their placements straight after they had completed their end-of-course exams and therefore probably in a state of some tiredness. The opportunity to have time free of thinking about academic content or work issues in the evenings and weekends is perhaps as much about rest and recovery as any other factor. Supporting this argument was the finding that fewer students made this comment during their second placement than their first, with some actually saying that they were now inclined to mull over interesting work problems outside work hours. As Victor noted in his second placement, at the time that he had just gained an extension of his contract " Now that I am being paid a bit more, I might start to stress a bit more about what I am doing" (Ro/4/9). The students also linked this change in behaviour to the consequence of gaining greater responsibility in their work in their second placements.

In summary by virtue of exchanging a university setting for a work setting in their co-op programmes, students in this study reported learning about the different constraints in the use of time between the two settings. This change in setting presented positive and negative effects of the working setting to the students and created a clearer view for them of the nature of working.

The next section discusses how two students learnt about some undesirable characteristics of the working environment.

6.2.6 Learning the ways of the business world

In this study two students reported learning about some undesirable characteristics of the business world through their work placements. These characteristics were the use of cheap, expendable labour, and the process of a company going into liquidation.

In Grant's second placement, he worked as part of a team on the shop floor of a manufacturing company. He formed an impression of how the company he was working for treated its staff:

> I have certainly learned a lot about some of the unwritten policies of the company. The company employs young people to work in the laminating department. They are paid low wages, and increases are small and rare. Progress in the company is made difficult, as the company only wants them as a source of cheap labour (Be/J2/3).

This impression had been gained by working in the environment and observing what happened to the staff. Grant commented that there was a very high staff turnover due to dissatisfaction with wages and working conditions. This experience had two immediate consequences for Grant. Firstly it made him realize that such treatment of staff was not good for the company. Secondly it encouraged him to go on graduate studies as he felt that higher qualifications would protect him from such treatment in his future career.

The other student had the unfortunate experience of being placed in a company that went into liquidation whilst he was working there. This experience is very unusual in a placement, being the only time this has occurred in at least the past 10 years in the BSc(Tech) programme. The student, Craig, was naturally disappointed by the experience but also felt wiser for it, commenting that "I have learnt the ways of the world quite quickly" (Su/2/2).

Craig began this placement part-time while he was still studying so that when he was first interviewed he was already working at the company. At that time he was very excited by the work and by the atmosphere in the workplace. He described

the work environment as young, vibrant and going places. As the company got into financial trouble, the atmosphere soured and became desperate, and Craig found himself taking on more responsibility as other staff left. Partly because it was his placement, and partly out of a sense of loyalty to the company, he stayed on until the end, leaving himself considerably out of pocket. The experience that he went through in seeing the social relationship changes in the company over a short period he rated as unfortunate but valuable at this early stage of his career. He noted that he learnt about several facets of working life:

> Hesitance. About rushing in and thinking 'I've got a great job and lots of money, I've got lots of things to do, I'm in a great industry, I can't fail'. Just to stand back and look at the big picture. An idea of when a company is in trouble, and probably I've learnt that when I don't see the next pay cheque, I'm out of there. Unless they have got a really good excuse. A lack of trust ... about some things that people say. A generally more in-depth understanding of people, and how they can operate and how they say they're doing things for other people and it's always for themselves (Su/2/2).

There is no doubt that this placement situation was an undesirable outcome for this co-op student. The experience could have potentially been very damaging to Craig's confidence in the workplace, and it is one which coordinators should do their best to avoid, and to provide support for students if it becomes unavoidable. However, as Craig notes, it provided him a great learning experience about social relations at a workplace under pressure. It gave him an appreciation of how the social interactions at work can change from happy and positive to very negative when commercial circumstances over which he has no control change.

As a postscript, a contact Craig made through his placement offered him a position for his second placement in a brand new company that was starting up. Craig undertook his second placement there and is now permanently employed in the company, which is doing well.

6.2.7 Summary of learning about the sociocultural setting of the workplace

In this study, students with little previous employment described how on placement they learnt about work ethics through experiencing the sociocultural

setting of the workplace. As newcomers to a community of practice they reported learning to model their behaviour on that of the 'oldtimers', the existing staff. Students with previous work experience reported learning less about work ethics.

For many of the students there was the uncertainty of entering a new sociocultural setting, building new relationships and learning the ways of practice in their new community. Through their placements they were being exposed to new people, new ways of thinking, and new routines, and some students found the transition from a different university setting hard. These experiences of being placed into a new sociocultural setting of the workplace did, however, lead some students to develop self-confidence, time management and interpersonal skills. The opportunities they had to become immersed in the activities of their workplace communities facilitated their involvement in social interactions. The next section investigates how those social interactions contributed to student learning.

6.3 Learning on placement as a social process

In this study, the placements brought students into contact with a work community, and as such they were exposed to the possibility of social interactions. Of interest in this study was the part that these interactions may play on their learning, and whether an examination of learning as a social process in the workplace could contribute to an understanding of a student's learning in their placement. As Moore (1986) argued, education at work "is the social process by which the neophyte comes to participate in the definition, distribution, and use of some portion of the social stock of knowledge in the environment" (p. 169).

As discussed in Section 3.2, learning as a social process has been described as including the social mediation of individual learning, situated activity, social mediation as participatory knowledge construction and social mediation by cultural scaffolding (Salomon & Perkins, 1998) and as arising among people engaged in activity in a social world (Lave, 1991).

The following sections discuss the students' reports of social interactions in their learning in their work placements. These include analysis of reported learning as a socially mediated, situated and participatory activity, the purpose of talk in learning, learning about the impact of communication breakdowns, and the importance of workplace relationships in learning, including the critical role of the work supervisor.

6.3.1 Learning as a socially mediated, situated and participatory activity

As Salomon and Perkins (1998) note, one of the simplest forms of social mediation of individual learning is instruction or training, and students reported learning in this manner. The students said they were told or shown what to do at work by their workmates. The trainer was either their work supervisor or one of their fellow technical staff, although the latter figured more in the day-to-day training according to the students. Nigel endorsed the way he was trained:

> The way they trained me was very good, the one person training me, and then they just eased me on to the job very slowly and it gave me a lot of confidence and I understood the job well, which is all I really ask at that stage (Gr/3/3).

Nigel felt the close training that he received was pivotal to his learning the work, increasing his confidence for doing the work, and in particular for understanding what he needed to do. Nigel's role in the placement was to analyse samples from the manufacturing line on a particular instrument. He commented on how his trainer and other workmates helped him solve problems with the instrument, until his own experience with the instrument allowed him to solve them himself. In this way Nigel was able to appropriate knowledge and skills shared within the community of his workplace.

Training can be viewed as a mechanism for appropriating the way of working in the community. Duncan picked up on this point in his first placement when he discussed what he gained from being trained alongside a workmate: "An insight to how they do it, they not only tell you but you can see, and you may choose to do it

a slightly different way afterwards, but it gives you an insight to maybe how others do it as well" (Ho/3/6).

Duncan's mention of the "insight" gained about how to do the work proposes that he saw that there were ways of working that were particular to that community of practice and that through training and subsequent participation in that community, appropriation may lead to transformation (Rogoff, 1995). Interestingly, Duncan noted that "you could choose to do it a slightly different way afterwards" indicating his perception that although the work was demonstrated in a particular way, the training had transformed his thinking such that he was prepared for ongoing participation in his role at work.

The existence of "insight" in the workplace also arose from an experience that Nancy had in her first placement. In this placement she was required to undertake a range of analytical chemistry procedures through following written company methods, but with little training. She related the following event in her journal:

> One situation that surprised me was a minor complaint passed on to me by one of the technicians who told me that I hadn't added sufficient reagent to my preparation. I was unaware that the amount was insufficient but had merely followed the method. I was told by my supervisor later who had noticed this, that I should have been able to see it. Having never 'seen' the right proportions of reagent before I found this difficult to comprehend. She did however agree that I had little experience in this area, and it is a skill that can be acquired over time (Wo/J1/7).

Despite following the prescribed method, written as a company document, Nancy made an error that affected her prepared solution. As she described, she had not had the experience to understand the un-written requirement to add sufficient reagent. This knowledge is evidently appropriated through working in that community over time, and distributed across the community in an oral way or not at all, leading in this case to learning by trial and error.

What emerges from the students' perceptions of their placement experiences is a picture of newcomer (student) dependence on old-timer (co-worker) for sharing of knowledge about the practice of working in their environment (Levine &

Moreland, 1991). In another example of this sharing of knowledge Grant commented on how important his workmates were to him learning his job:

> Well some individuals were responsible for me learning everything because ... I was given a couple of notes, you know, just with the basics on what to do and some of the employees there just showed me how to implement them and a couple of tricks to get a job done properly (Be/3/4).

Grant's mention of "tricks to get a job done properly" points to an in-house sharing of knowledge that is specific to that community of workers. Here again it was evidently not something that was written down in the instruction notes that he mentioned earlier in the statement. Grant commented that the notes just gave the "basics" and he learnt the 'finer details' from the workmates. This example further illustrates that much of what is known and practiced in a community such as a workplace is not written, but shared amongst the community in a socially mediated way (Lave, 1991), and that learning within such a community can be conceived of as a situated activity.

Learning as a situated activity was particularly evident in student reports of learning technical skills. Lucy, Nancy and Craig all provided examples of learning directly from the experience of their workmates. Lucy commented that in her first placement in a molecular biology laboratory that "it wasn't like there was a manual I could look up or anything", and that she preferred to talk with her workmates about "their experience with doing things, that they've gotten a lot of knowledge that they can teach you" (Str/3/5). In her work, Lucy had no documentation to refer to, as there was no written way of doing the tasks across different workplaces, so the knowledge was confined to discussions within her work community. This community revolved around commercially sensitive work in which the methods of doing tasks have not been published in any form of public format.

Nancy had a similar view of socially situated learning in her first placement in a research environment:

> It was just passing on their knowledge to me, something that you can't really look up in a book, you have to experience it. Because they've had the experience in the lab of working with extractions and things like that, which is stuff that I hadn't done before (Wo/3/8).

In her work in a chemistry laboratory Nancy had become aware that knowledge resided in the experiences of her workmates. Through participating in that workplace in a productive and meaningful way, she was able to share in that knowledge and experience through taking a legitimate part in discussions on what had to be and what was done.

Craig provided a third example of learning as a situated activity from workmates. In his work in the information technology sector, he described how he learnt from what his workmates were able to do technically: "I learnt a lot from people because the internet and computers, especially two guys at work, I have learnt a lot from them, just by conversations and what they do, I sort of just follow examples" (Su/3/5).

Craig's report of learning through example and talk is typical of the notion of apprenticeship, in which learners engage in authentic activities whose meaning and purpose are socially constructed through interactions with workmates and the tools (i.e. the computers) of the workplace. This sentiment was echoed by Donna, who felt that it would have taken her a lot longer to learn skills at work, particularly on the computer, if she had had to read manuals rather than talk to her workmates (Ni/3/5). The experiences of Lucy, Nancy, Craig and Donna provide some indication that this type of learning is an important mechanism for learning contextually-specific technical knowledge and skills in work placements.

However, students not only reported learning of technical knowledge and skills through their participation in a social community. They also reported learning about facets of a community of practice such as teamwork, information sharing and information withholding. These are now discussed.

The importance of teamwork in an organisation was highlighted by Vanessa and Rick. During her first placement in a science research organisation, Vanessa observed that all the people at work have a role to play:

> I have learnt that everyone in the organisation has their own individual talent, skill or piece of knowledge on an aspect of science which no-one else may have. Therefore everyone becomes an important and key component of the organisation (Sto/J1/4).

Through participation in her placement experience, Vanessa had been able to observe the contributions that all the members of that research community of practice were making. This example shows that it is possible for a student on placement to learn about the roles that members of a research community undertake and how the organisation fits together. In his first placement, Rick worked in a research and development group within a manufacturing company and he also commented about how people work together towards a common goal:

> I think it's rewarding when you see, you just sort of see all your work coming together with everyone else's, how they seem to form a good product. I think that's how people know, is when their work fits perfectly with everyone else's. Sort of like an intricate jigsaw puzzle, everyone's building separate pieces. You might not know while you are building the jigsaw puzzle whether you are building it properly but as soon as you put it all together it's plain to see (Pa/2/12).

Rick felt that he had gained an understanding of the research and development process through being a part of a team of people working together to form a product. His analogy of workmates working on pieces of a jigsaw indicates a belief about interdependence that may only be understood by being immersed in the situation.

Related to teamwork is the sharing of information around the workplace. Rick also commented on how ideas and knowledge were shared amongst the team:

> I saw one example at [my placement company], a whole rack of journals, the computer programmemer might be reading something, he will see something that might be applicable to

> someone on a totally different sort of field but say 'have a read of this, it's quite interesting, you might find this handy' (Pa/3/5).

Rick viewed this form of social sharing of information as very productive in his work environment and he commented that, after a time in his placement, he began taking work journals home and reading them to further his own knowledge. His observation of the role that journal reading played in his placement amongst the team of workers led him to appropriate this way of working, transforming his own practice.

Jill experienced similar information sharing in her first placement. She worked similarly in a research and development area of a manufacturing company and described how information would be passed around:

> We get all the different serials come through and they get passed around the departments and like if you see something that might be relevant to one of the people's projects you just email them and say you should look at this (Le/3/5).

These experiences of information sharing amongst the community of practice at work can be interpreted as indicating how knowledge can be distributed across a community. However two students in this study learnt that knowledge is not always equally distributed in the workplace, as noted by Salomon (1997b), and that it can be used to wield power. Grant wrote in his journal about his experience in his second placement:

> I later learned that in industry, employees are reluctant to share information with newcomers. To them, knowledge is power, and their experience gives them a sense of superiority. This scenario not only occurs with the floor workers, but with management and leaders as well. I am fortunate enough to be one of the more experienced workers in my department and have earned the necessary respect from my co-workers. Because of this, information is shared with me and my opinions are respected (Be/J2/1).

This "knowledge is power" facet of working life had been demonstrated to Grant through his experience of working with people. During a later interview Grant also raised the issue of whether information is sometimes withheld at work, noting

that he had spoken to "a couple of guys who'd been working there for years and they certainly think so" (Be/4/6). Grant described it as 'fortunate' to have been working there long enough that he had gained enough respect to be included in the knowledge-sharing. He noted the need to "earn" that respect before he became privileged with the information. This observation raises a question about accessibility of information to students on placement, and whether their status as students inhibits their opportunities to learn until such time as they are accepted by their workmates. Gamble (2000) also found evidence for this withholding of information in her study of craft apprentices, as did McGee (1996) and Turnbull (1997) in their studies of teacher practicums. Members of a community of practice may be reluctant to share information as they fear being displaced (Billett, 1999; Lave & Wenger, 1991). This question has implications about preparing students for undertaking work placements, and assessing their ability to learn on placement if they should find themselves in an information-repressed position.

In summary students in this study have reported learning that can be conceived of as socially mediated, situated and participatory activity in their work placements. They placed emphasis on the role that their workmates had in training them to do tasks, in providing insight and tricks and knowledge to get the work done. The students' learning was by oral means and often involved information that was highly situated, and shared amongst the community at work. This sharing led to some students describing how they adopted the practices of their workmates, becoming enculturated into their way of working. Participation in the community of practice at work also led to opportunities for learning about teamwork, information sharing and information withholding.

As noted above, much of the students' socially mediated learning occurred using oral communication. The next section examines some of the purposes that talk can have in learning in a work placement.

6.3.2 The purposes of talk in learning in the placement

Students in this study reported that talk in social interactions had several purposes in their learning in their placements. These were the opportunity to ask questions,

to clarify understandings, to learn what other members of the community were doing, and to obtain a view of their workmates attitudes to their work and the company. This talk was reported as occurring in both formal settings, as in instruction sessions, group discussions or meetings, or informal settings such as tearoom chats.

One purpose of talk was the opportunity to ask questions, which gave Mike access to historical knowledge of old research trials in his second placement. Mike's job was to assemble a database of research trials that had been carried out by the staff of the institute where he was working over a number of years. He soon found that he learnt more by discussing the work with people who knew about it than by reading what had been written about it:

> The best information I've got is from, well, the most interesting information I've got is from talking to people. I think you get more of a fuller idea of what was actually going on. Rather than just read through these old files from 1960 (Mc/4/12).

Mike noted that he got a "fuller idea" of the historical knowledge by talking than by reading. He felt that his colleagues were able to explain the trial work more clearly than it had been written, and provide him with a richer picture of the knowledge that resided in the heads of the old-timers within his community at work.

Secondly, in Martin's case, the chance to talk about his work with workmates helped him clarify his understanding:

> It sort of gives you a bit of confidence in the fact that you know you could talk to someone, put your ideas up and they can look at them and say yes-no and give a reason why and they often, well I'd say they always did that (Ri/4/9).

Martin used talk at work as a sounding board, a chance to express his ideas and discuss progress. These discussions can be viewed as a social negotiation of understanding, in which both the student and his workmates come to a mutual

understanding of their practice, using talk as a vehicle for accessing each other's thoughts.

Thirdly, five students in this study mentioned that talk in the formal setting of meetings was a useful way for them to learn about what other members of their community of practice were doing. For example, Jill commented that she learnt about what everyone else did at work:

> We had meetings every Monday and everyone reported on what they were doing and how they were going. I mean just through those meetings I knew exactly what everyone was doing, what projects they were on and how their projects were going, and it just helps, it's really interesting to know what everyone else is doing (Le/3/5).

These students felt that meetings were a useful talk tool for learning about other activities within their community of practice. This formal communication environment provided an opportunity for the students to feel included in their work communities and gain exposure to the broader undertakings of their placement company.

Fourthly, talk in the placement gave students access to the attitudes of the workmates towards their work and the company. This talk was more likely to occur in informal talking settings such as the cafeteria at work. This was reported in a general way, such as Jill's impression that "you learn a lot just from people's discussions, a lot is said in the cafeteria" (Le/3/4). But in Grant's case he learnt particularly about how his workmates viewed the organisational culture:

> I think a more accurate view of the company comes from your everyday workers, you know, and they sit there in the shed having a smoko [tea-break] ... just by listening to what they have to say about things, you can get a general feel of what the vibes are like (Be/3/3).

Grant was an "everyday worker" in his first placement. But as a placement student he had also been given the management view of the company when he began his placement. Through his placement experience he was able to hear about two

views of the company, and he had learnt that there were some discrepancies between the two views.

In another example of learning about workmates' attitudes, in her second placement Jill had experienced the operation of the "grapevine" as a way of talking for sharing of views and information about the dairy factory she was working in. The official information channel of the factory site newsletters had created talk amongst her workmates about their own futures. Jill was able to relate her experience of this talk to her university studies:

> It was quite funny, from the technology paper last year, was that the biggest information carrier is the grapevine, and it's so true. Like people would come back from smoko [tea-break] and go 'oh such and such a site is getting shut down' and all that goes around. And everyone thinks if the milk disappears 'are they going to shut down one of the plants at [this site]', and 'am I going to have a job in 6 weeks?' (Le/2/8)

Jill sounded quite astonished when she discovered the use of the grapevine in practice at her work placement, as though she hadn't expected to experience what she had learnt at university in practice in the workplace. She had had the opportunity to learn how informal talk was important in sharing information about the company, and the effect that talk could have in the workplace.

In summary students in this study learnt about purposes of talk in their placements. The talk was both formal and informal, and ranged from instructions on skills to discussion of ideas to chat about the company. Talk provided a vehicle for questioning, knowledge-sharing and an unofficial outlet for expression of opinion. It contributed to student learning in the workplace by allowing the students to participate in social interaction. These social interactions mediated by talk contribute to the development of relationships. The next section explores what and how the students felt they learnt about developing relationships in their placements.

6.3.3 Learning about the importance of work relationships on placement

A third aspect of learning as a social process commented on by students in this study was the importance of work relationships in their placements. The social relations at work have been argued to contribute to the curricular content of a student's work experience (Simon et al., 1991). As these relationships may be important to a student's ability to carry out tasks, further their career and feel emotionally secure in the workplace, it was of interest to understand the perceptions that students in this study held about learning about workplace relationships in their placements. Students reported learning about the importance of supportive relationships with workmates, and how to build good relationships with their workmates.

Firstly, students in this study commented on the support that they were given in the workplace, and how that influenced their emotional well-being and motivation towards work. They were able to recount situations in which they felt well supported, but also situations where they felt they lacked support. In discussing support, Kara was particularly affected by social relationships at work, and she had commented in each of her interviews about their importance. Towards the end of her last placement, she had this to say:

> I think a major thing that influences what you learn is the atmosphere and I mean a good atmosphere and you're getting on well with everyone or you feel like you're appreciated for what you're doing, it makes you want to learn more about the organisation and everything else that you're doing, whereas in an opposite sense you're kind of discouraged (De/4.4/5).

Kara made the point that having a good relationship with her workmates was important for emotional support. This point was emphasised to Kara in the early part of her second placement, during which she was given little support by her workmates, and she felt unhappy and undervalued. During this time Kara was working closely with another student, Kathy, who commented that "we felt quite unwelcome" (Ba/4.2/6) in the workplace. Kathy and Kara were working on a contract that the people around them in the workplace knew little about and

showed no interest in, which Kathy found very disappointing. At this point in the placement Kathy reported learning very little (Ba/4.1/7).

The role of emotional support in encouraging learning was particularly mentioned by the students in relation to asking questions and making mistakes. For example, Kathy explained how important supportive relationships were to her:

> Talking to people is very important, especially if you feel comfortable with that person, that you can ask questions, which to you seem completely stupid, but they might not be (Ba/4.4/13).

Kathy made a distinction between her experiences in her first and second placement. In her first placement she felt well supported and able to ask questions, but in her second placement, Kathy felt there was a lack of interest in her work and hence she felt unable to talk to workmates about it. She found the latter experience de-motivating.

Equally Rick reported in his first placement that "everyone's been very, very good to me. They don't mind me too much when I don't do everything quite right, bug them with stupid little questions and things like that" (Pa/2/2). Prior to this placement Rick had said that "if I have a good support team I'll be OK. Then I am not too afraid to try because if I fall there is someone there who will catch me" (Pa/1/15) and his experience on placement had borne out his earlier belief due to the support he felt he received at work. For Rick, who had little prior employment experience, this level of support may have been particularly important. He felt that having supportive relationships at work gave him opportunities to learn.

Secondly, students in this study commented on how they came to understand about how to build relationships with their workmates. In James' second placement he spoke about how he learnt how to work with his workmates:

> Just by keeping your eyes open and your ears open. Just talking to people too, you know, you get to be a bit more friendly with them and you joke with them about things, and then they open up a bit more (Sk/4/10).

James rated the use of observation and socialising as important elements for his building relationships with his workmates. Similarly Karl talked about observation as being the key to understanding how to approach and talk to his workmates. During his placement his role came to include supervision of staff and he commented on the importance of his relationship with his staff for being productive at work (Fr/3/3).

Learning more about their workmates at a personal level was another key aspect to building relationships at work reported by students. Rick summed this up in his placement:

> Everyone's friends with everyone else, and so you share a bit of your life with them. The people in my office will talk about their kids, so you pick up the little things like that about people. Small talk (Pa/2/13).

Rick described how this sharing of information with his workmates' about their personal lives made him feel more relaxed and comfortable at work. Mike spoke about how learning to fit in with people at work through developing personal relationships with his workmates was a key outcome for him in his placement:

> I think probably the biggest thing was just like fitting in to the working environment, I guess socialising with people. A lot of the people were quite a bit older than me and from a lot different backgrounds, so that was good (Mc/3/4).

Mike felt that getting to know his workmates on a personal level was important to his success in his placement, emphasising for him the value of building good relationships in the workplace. In particular, Mike mentioned how he had participated in social cricket games during lunch-breaks and that this participation in a shared endeavour had helped him get to know his workmates.

The value of activities shared with workmates outside of work in helping build relationships with them was commented on by a number of students. Duncan found that by his participation in social sports activities in his placement he made friends that he kept for the duration of the placement. He noted that "when I first

started down there [at work], I went straight into playing touch [rugby], and the people that I met there, would be the ones that I talk to now, have contact with" (Ho/2/17). The social sport provided a vehicle for Duncan to get to know his workmates and establish a friendship. A similar type of experience was valuable for Victor:

> We had the R & D Annual Ball bash and we all went out and played golf. Which is really good. I've never played golf, but I guess that it was more of a chance to talk to people and I got to know a couple of guys quite well there. One thing about the golf, it gave me a chance to sort of talk to people who I wouldn't normally interact with in my sort of general day to day work, because I wouldn't normally have a chance to sort of talk to them, because they're just never around me (Ro/2/19).

For both Duncan and Victor the social sport had allowed them to build relationships with workmates that they may not have otherwise met in the course of their work. These opportunities hold the potential to provide the emotional support that has been described above as contributing to a comfortable working environment leading to better learning at work.

Completing this examination of the role of social activities in building work relationships is to relate a quite unusual case. Rick experienced an interesting 'bonding' session with his workmates on a social fishing trip:

> Well, we went on a fishing trip the other week and well, I felt sea-sick, a couple of the other guys felt totally sea-sick, so I think that does help. Going through a personal shared tragedy, there's no better way to bring someone closer, making a friend, than to go through a similar tragedy. If you have ever been sea-sick, you'll know how terrible it is, so there's just a lot of compassion for everyone else (Pa/2/13).

Rick was able to see how sharing an unpleasant experience with colleagues had given him something in common with them, that he could empathise with them, and as such felt closer to them. This was an unexpected learning outcome for Rick!

The importance of relationships established during their first placement became apparent to three students when they returned to the same workplace for their

second placement. For Victor, it gave him confidence to know that he already had a relationship with the people at work:

> It was more like meeting up with old acquaintances as such, there wasn't the intimidation of new people around, there were a few new people but I was reasonably confident stepping in and pretty much instantly got into the groove of it (Ro/4/6).

In a similar vein Vanessa felt that she was able to build better relationships with her workmates second time around, as she already knew and understood them: "I think now that I get on a lot better with people, I understand people a little bit more and you become better friends with people, because I'm not the new kid on the block anymore sort of thing" (Sto/4.1/7). Victor and Vanessa expressed the belief that the experience of their first placement had developed in them confidence and understanding in what it was like to work alongside their workmates. Throughout the interviews conducted during their second placements, these themes returned in their perceptions of their work, and it seems clear that their establishment of good working relationships in the first placement had had a marked effect on them. As Donna commented about her return to the same workplace for the second placement:

> It's kind of like a second home I guess, coming here I feel that I fit in so well and I've made some friends. So when I take a day off, it's like I miss it and look forward to coming back (Ni/4/7).

Every employer would be glad to hear that sentiment!

In summary, all students in this study described that they learnt about workplace relationships during their placements. They reported that being supported by their workmates was important to their emotional well-being, and to their learning through creating conditions that enabled them to ask questions and make mistakes without concerns. They described how they learnt how to build relationships at work through observation of their workmates, socialising, talking on a personal level, and participation in sports activities and outings with their workmates. Some students learnt about the value of workplace relationships when they returned to the same workplace for their second placement.

One of the key relationships that students on placement need to make at work is with their work supervisor. The next section in this analysis of learning as a social process examines students' experiences with work supervisors.

6.3.4 Learning about working with a supervisor

In a co-op programme, the work supervisor is an employee of the placement company who takes overall responsibility for the student's work while on placement. The role that this person plays can vary between placements: at one extreme the supervisor sets the workload and may only see the student once a week, while day to day supervision is carried out by technical staff (workmates); and at the other extreme the supervisor works side by side with the student on a daily basis. The first mentioned style is more common in private commercial companies, while the latter is more common in research institutes and local government organisations. Due to this variation the students experienced a range of relationship experiences with their supervisors.

It has been argued that one of the roles of a work supervisor is to help a co-op student to develop as a professional (Gibson & Angel, 1997). This argument has led to research into whether work supervisors could take on the role of a mentor to a student on placement (Gibson & Angel, 1997; Ricks & Van Gyn, 1997). The research showed that while mentoring relationships did develop between co-op students and their supervisors on placement, the incidence of mentoring relationship was no greater than existed for non-co-op students through their work or schooling (Ricks & Van Gyn, 1997), and that students showed a preference for a separation between the roles of mentor and supervisor on placement (Gibson & Angel, 1997). Indeed it has been argued elsewhere that the roles of work supervisor and facilitator of learning are completely at odds (Hughes, 1998), given the conflict of interest between the development of the student and the needs of the employing organisation.

Students in this study reported feeling supported and motivated by their work supervisors in their work (in 30 out of 39 placements), and revealed that elements

of mentoring may have been present in their relationships with their work supervisors.

Prior to their first placement students expressed concerns and uncertainties about how they would relate to their work supervisors and their expectations. For example Donna commented that "I don't want to show my unintelligence [sic]. He might be disillusioned with me" (Ni/1/8). Donna was worried that her supervisor, who she perceived as being very intelligent, might think she was not. However her fears were allayed after working with him in her placement, as she commented that "he is really approachable, he is a really nice guy"(Ni/2/11). Donna's reports about the positive feedback she received from her supervisor indicate that her previous concerns were not realized. The opportunity to form a positive working relationship with her supervisor and make it successful increased Donna's confidence about working with her placement company.

The enthusiasm of her supervisor in her placement, working as a research technician in a university, was what Christine felt was the most important influence on her learning:

> It's definitely your supervisor's perception of what you're doing and why you're there. I think if ... they're really into ... if they're really enthusiastic about what they're doing, and they are willing to you know to go that extra bit to show you how this works and what it does and that ... that helps a lot (Ha/4/6).

Christine commented that she had a really good relationship with her supervisor, and that she felt respected and trusted for her work. Hughes (1998) noted that the development of trust is critical in the facilitation of learning, which may lead to a supervisor taking on the role of a mentor. The positive relationship with her work supervisor had made a good impression on Christine and she felt motivated to learn.

The importance of building a positive relationship with her work supervisor was a key learning outcome for Vanessa in her two contrasting placements in the same research institute. In her first placement she was supervised by a male scientist

who had been with the organisation for several years, and in her second placement she was supervised by a young female scientist who had just joined the organisation after completing her doctorate. She had very different experiences with her two supervisors. Her relationship with her first supervisor was awkward:

> He's a really nice guy, but he's just frustrating because he won't, whether he forgets to tell you or just doesn't explain things properly in the first place. Then I'll find that I didn't do something or I didn't do it properly and I would have to go back (Sto/2/14).

Vanessa had experienced communication problems in understanding her first placement supervisor. She commented that he had a strong accent and that it was sometimes difficult to understand what he had said, as well what he wanted her to do. As Billet (1999) noted, expert guidance is critical to learning in the workplace. Vanessa felt de-motivated by her experience and came close to withdrawing from the co-op programme. However she persevered and undertook a second placement in the same organisation. Her relationship with her second supervisor was totally different:

> She's a lot younger and she's just got her PhD and she's more, she knows what it's like to be a student and, yeah she's closer to my own age so that also can be a big thing, and because the job I'm doing at the moment is quite a physically demanding job and because she's a female as well she can understand there are limitations to what I can do, which is good (Sto/4.1/3).

Vanessa felt that she could relate more to her younger, female supervisor because she felt her supervisor understood her needs more. This was evidently a better match for Vanessa than an older, male supervisor. This finding has implications for enhancing student learning on placement by matching students to supervisors. This matching may prove too idealistic given the constraints of other factors in locating placements, but the coordinator may need to consider the fitness of the match of student to supervisor in support and assessment of the student's placement.

Vanessa went on to explain how she felt her second supervisor really helped her learning, indicating that her supervisor may have taken on a role which had some of the characteristics of a mentor:

> [She] forces me to read, but she said to me the other day I don't want you to just be a technician and just fire out the results, and say here they are ... she wants me to actually ... she forces me to learn. She'll fire questions at me and I get all nervous and say 'oh, is that the right answer', and I also looked a bit worried the other day ... she said 'don't worry, I'm just trying to get you to learn and think for yourself'. It's good (Sto/4.3/10).

Vanessa described how her supervisor 'forced' her to learn, and while the notion of force would not be one that would normally describe a mentoring relationship, from Vanessa's subsequent comments about her supervisor's guidance and support it is likely that force could be substituted by encourage in this situation. It is clear from these comments that Vanessa's supervisor was keen to provide Vanessa with opportunities to learn and understand her work, indicating that it was a very positive relationship.

Students in this study described how a positive relationship with their work supervisor was important to their learning. They attributed factors such as their supervisor's approachability and feedback, their enthusiasm, their empathy and their encouragement as influences on their learning. There was some evidence in this study that work supervisors exhibited some of the characteristics of a mentor in their relationship with students.

The students in this study not only reported the importance of developing relationships themselves within the placement, but they also commented on what they learnt about how management and staff relate to each other. This is discussed in the next section.

6.3.5 Learning about management/ staff relationships in the workplace

Through working on their placements, some of the students (5/22) in this study reported learning about the culture of relationships between management and staff

within their workplaces. In particular three students noted differences between management and shop floor staff in industrial workplaces, and two students learnt about differences between scientists and technicians in research institutes. This section discusses their self-reports.

6.3.5.1 The Industrial Context

A division between management and staff in their placements in private industrial companies was described by Karl, Martin and Grant. Karl had a year-long placement in an automotive parts industrial plant. His role was based in the management side, and for a time during his placement he was even supervising production staff. This gave him the opportunity to see how work management and the shop floor staff related to each other. He commented that "I'd say that the floor staff were quite timid about approaching, like approaching management, to speak to management, whereas management would speak easily with floor staff" (Fr/4/6).

Karl felt these communication difficulties that he had observed, and experienced himself, between management and shop floor staff could be explained by territorial behaviour, as he noted:

> Probably more that the floor staff wouldn't speak to the management inside the office. Might laugh about it but it's quite, it's something they discussed as a major problem not long before I left, is that for the floor staff, the boundaries of the plant are those doors to the office. They don't want to go inside those doors. They don't like it. But I mean if you ran into one of them on the shop floor, you probably wouldn't get them to shut up. Like if they saw you on the shop floor they'd tell you, but they wouldn't come to the office and tell you (Fr/4/6).

Karl explained that the shop floor staff were allowed to go into the management area but didn't want to. He said that it was "mystery land" to them. It was Karl's perception that this division of space was leading to a communication barrier between management and the shop floor staff, which could influence the relationship between the two staff groups.

A similar spatial divide leading to a relationship divide was experienced by Martin in his first placement working in a plastics manufacturing plant. His placement was in the management group but he was required to work on the shop floor on the first days of his placement, to learn about the production processes. This gave Martin the opportunity to talk with the shop floor staff and he discovered a difference between them and management:

> There seems like a gap between being in here [the office] and working with these guys and being out there [the shop floor]. I seem to be able to relate to both of them, but there's definitely a difference between dealing with the operators and the managers (Ri/2/5).

Martin had previously worked in several holiday and part-time jobs, but had never before worked on the management side in the office. His experience of working on both the management and the shop floor sides had shown him that management can have different views to the floor staff, who had expressed some negative feelings towards their management. As Martin had expressed an interest in a career in industrial management, this experience of being exposed to both viewpoints on his placement may prove valuable to his future.

The perception that management and shop floor staff see work conditions differently to each other was also noted by Grant in his placement in a sawmill. He noted "that [the floor staff's] complaints aren't unjustified sometimes because, you know, as a manager may see it, they're just whinging. But it's good to be in their situation just to see what things are like" (Be/3/3). Grant felt that the opportunity to experience (by being situated within) the same conditions as the floor staff had given him a better understanding of their position. He described how the office staff would occasionally walk past the factory and his co-workers would call out to them to come and get their hands dirty. His observations can be interpreted as learning about the relationship between management and shop floor staff in an industrial company.

6.3.5.2 The Research Institute Context

The distinction between management and staff in industrial contexts is replaced by scientists and their technicians in research institutes. Although the nature of this scientist/technician relationship could be viewed in a different way to traditional management/staff situations, two students in this study noted learning about the relationship between scientists and technicians. Duncan and Vanessa worked as technicians in research institutes for their placements.

In his agriculturally-based research placement Duncan felt that there were three distinct groups, the scientists, the technicians and the farm staff. Although all worked together at times, Duncan saw them as separately engaged in their work. He particularly noted that they were located separately in the workplace and that their talk was different. He commented that scientists were "a lot more serious and they talk about their work"(Ho/2/8), whereas the talk amongst the technicians, with whom he identified, was more general and not related to work.

Vanessa carried out two work placements totalling 12 months in the same research institute. After her first two months in the institute, she felt there was a clear division between scientists and technicians in her workplace:

> I've worked out there is definitely a hierarchy of the system in [the research institute]. Like there is the boss, the general manager, then there are the scientists, then there is a big division between the scientists and technicians (Sto/2/7).

At the time, Vanessa saw that division unfavourably and felt negatively towards the scientists:

> Well ... even in my view, like scientists get you to do things, like the menial tasks that I guess you're here to do as well, and they sort of congregate together and do their own thing, and technicians are in the lab to do basically all the work for the scientists. Sometimes I think the scientist gets all the credit and the technician gets let down a little bit (Sto/2/7).

Like Duncan, Vanessa formed the view that the scientists were set apart from the technicians. She also saw the relationship as exploitative, with the technicians doing all the work, and the scientists claiming the rewards. Vanessa had even noticed the physical separation between scientists and technicians, as she commented that "even the scientists are up here on the second floor and the technicians are on the bottom floor" (Sto/2/7). She felt this spatial arrangement reinforced the feeling of separation.

In her first three-month placement Vanessa had an unhappy and unproductive relationship with her work supervisor. This was evident in comments that she made about her work and may have contributed to her feelings of division between the scientists and technicians. Vanessa's second placement at the same research institute was for nine months. Towards the end of that placement, she still noted the division, but Vanessa's understanding of the scientist – technician relationship appeared to have changed:

> There's a physical division with the scientists being upstairs and the technicians being downstairs, but I'm not sure, I guess because the scientists are doing the research, you know, reading the papers and putting together the results and things like that whereas the technicians are working down on the floor, making things happen. So it is quite a symbiotic relationship I suppose. The technicians need the scientists for information and the scientists need the technicians to do the work (Sto/4.3/9).

It is possible that spending a longer time in the workplace, and having a better supervisor relationship, had led Vanessa to develop her views of how scientists and technicians worked together. The opportunity to see the workplace a second time around and under the guidance of a scientist that she could relate more easily to may have led to this change of view. This examination of Vanessa's experience shows how the supervisor-student relationship could affect learning in the placement, and how a student can perceive the relationships between management and staff (scientist and technician in this case) in the workplace.

In summary, learning about attitudes and behaviours in workplace relationships between management and staff has been described by some students in this study.

They noted communication difficulties and differences in viewpoints between the groups that they attributed to the occupation of separate workspaces by management and staff. Examples of these differences were drawn from both the industrial production arena and the research institutes. The use of space, and communication, are attributes of the socially-constituted environment of the workplace, and these students have perceived that they learnt about this environment during their placements. The communication difficulties caused by differences in attitudes and behaviours between people at work can lead to breakdowns in communication and some students in this study experienced such breakdowns in their placements

6.3.6 Learning about communication breakdowns in the placement

A final aspect of learning as a social process mentioned by students in this study was learning about what happens when social interactions in the workplace are defective, sometimes called communication breakdowns. Three students in this study reported experiences of communication breakdowns in their placements. Their perceptions were that the breakdowns were caused either by poor management practices or personality clashes.

One breakdown was reported by Grant, who had a salutary tale to tell in his journal regarding his second placement, where he worked on the shop floor in a manufacturing company:

> Very often the foreman will tell one person what is to be done, and a breakdown in communication often occurs. I have spoken to management about this and for a limited time we had team meetings, and everyone knew what was happening. This has now ceased. I find it quite amusing that we are expected to work as a team, but are not addressed as a team (Be/J2/1).

Interestingly Grant experienced a communication breakdown and had the courage to try and rectify the situation with his managers. Ultimately he felt that his action failed, and this left him wondering about the management practices within his workplace company.

Another communication breakdown attributed to poor management practice was reported by Jeff. He had an experience where he didn't get on with a workmate in his first placement. He worked in a small forestry team, evaluating trees for milling, and one member of the team always wanted to have the work done his way. He felt that he learnt from that experience the value of having clearly defined roles in a team:

> Yeah you've got to have a certain team leader eh! Someone that makes the decisions, or else they just argue. Someone who is in charge, I think when we were working together, [the manager] should have said one of us was in charge (Rh/2/14).

Both Grant and Jeff experienced the problems of communication relationships in a team, and both concluded that poor management of the situation had led to the communication breakdowns.

A communication breakdown due to a clash of personality was described by Jill in her first placement. She related the following scenario:

> I can definitely see communication problems between people in the office and people in the Development Centre. I can definitely see like barriers between the boss, and [my workmates]. Because [my workmates] are in the plant and they know exactly what goes on in the plant, and then [the boss] is kind of telling them what to do and they'll say 'that machine doesn't go', and he'll say 'yes it does', and they go 'oh OK then of course it does' and then he expects them to use it and it doesn't go. It's the first time I've seen it in front of me, the clash of egos, like 'don't want to do that because it's not my idea'. It's not major but it's definitely there (Le/2/11).

Jill expressed disappointment and concern over her experience of this communication breakdown. She later recounted (Le/2/12) how she had been placed in an impossible position of trying to please her immediate supervisor and his supervisor, due to their clash of personality, which had made her feel very uncomfortable.

The opportunities that these students have had on placement to experience first-hand communication breakdown in the workplace are clearly not desirable in the

sense that they have a negative effect on their placement experience. However, if constructively analysed by the student and supported by the coordinator, they can be viewed as having contributed to their learning about workplace relationships, and their influence in a community of practice. Learning about the influence of those relationships on placement is discussed more fully in the next section.

6.3.7 Summary of learning on placement as a social process

Undertaking work placements as part of a co-op degree introduces students into the community of practice of a workplace. The co-op students in this study have reported learning through and about the community of practice in their placements.

Considering learning from a sociocultural perspective, students discussed social mediation of learning through instruction of how to do tasks and operate instruments. They noted their learning through participation in work tasks, in which they were given access to the work knowledge and experience of their workmates in a socially situated manner. They emphasised the important role that talk had in their learning about knowledge, skills and workmates' feelings, and facilitating their participation in social interaction. They highlighted the role that supportive relationships at work played in their emotional well-being and learning.

Participation in the social environment of the placement led to learning about teamwork, about how information is shared (or not shared in some cases) across the workplace. Participation led to learning about building work relationships through activities both at work and in a social setting. Students emphasised the importance of those work relationships to them, with a key relationship being that with their work supervisor. Building successful relationships at work enhanced the students' enculturation into their work community.

To complete this chapter's investigation of student learning on placement through the lens of sociocultural views, the next section considers how student reports of learning on placement could be viewed as learning as mediated action.

6.4 Learning on placement as mediated action

As discussed in Chapter 3, the enculturation of a newcomer (e.g., a co-op student) into a new community of practice (e.g., a workplace) can be seen to occur by learning through engagement in authentic activities and the use of cultural tools (knowledge, language, artefacts) that are characteristic of that community (Brown et al., 1989; Cole, 1991; Resnick, 1987). These tools are conceived of as mediating the actions, including learning, of the members of the community (Wertsch, 1991b). The tools also not only mediate social interactions within the community, but are themselves "products of sociocultural evolution, and are inherently situated in sociocultural context" (Wertsch, 1991a, p. 91). Participation in the use of these tools in the manner of an apprentice may permit the student access to the meaning of what it is like to practice in their chosen field. This section then examines what and how students in this study reported learning through the use of tools such as language, artefacts such as dress, and ways of working that contribute to the constitution of the workplace culture (Hickson & Pugh, 1995).

6.4.1 Learning a specialised language at work

Communication, plays a significant role in the manifestation of culture, in being the "product of socially and historically situated discourse communities created and shaped by language" (Kramsch, 1998, p. 10). This positioning of language at the source of a cultural community has also been proposed by others (Cole & Engestrom, 1997; Goodwin & Duranti, 1992; Vygotsky, 1978). Additionally Simon et al. (1991) list the language of work as an important feature of the workplace that an effective worker might need to know to do their job. Many of the students (16/22) in this study reported encountering a 'new' language of work in their placements. This language consisted mainly of technical terms, abbreviations and acronyms. The students reported initial feelings of confusion,

frustration and alienation when they encountered this new language, but found that they gradually became 'enculturated' into its use and came to adopt it.

For example, in Lucy's placement in a research and development group within a manufacturing plant, she commented that "to start with I would just kind of listen in and wonder what the heck they were talking about and then somewhere down the track I'd go 'oh that's what it is'" (Str/4/14). The exposure to the new language left Lucy feeling confused and uninformed, as though she had not been admitted to the inner workings of her community. For Grant, not understanding the language of his workplace led him to feel frustrated and demeaned in his first placement because he didn't know the language of his workplace: "Very frustrated. Because I got the feeling that some of the workers look down on me, you know, might have thought that I wasn't too sharp because I didn't understand what they were saying" (Be/2/4). Grant's perception was that the 'language barrier' had led to his alienation from his workmates. He commented elsewhere that he was given little formal training at the beginning of this placement and it can be assumed that explanations of in-house language were not included. It is possible that workers could withhold information about language from newcomers in order to retain some power or superiority over them, a notion that was touched on in Section 6.3.1.

Abbreviations and acronyms were particular elements of language that many students found themselves struggling with in the early stages of their placements. Nigel's experience was typical:

> Abbreviations are a big thing in those sort of companies, laboratory abbreviations for a start, the machine they use and the test they do, but there is also a lot of jargon on the production line in the brewing process, it's all a different language to start with, so the first few weeks there was a bit to learn (Gr/3/5).

Nigel experienced a steep learning curve early in his placement in not only doing the tasks asked of him, but also understanding the language of the workplace. Karl's experience of acronym use was such that in the company he worked for, every company document had an acronym manual at the back. He noted that "I

got this email from Australia that was 200 hundred pages long, and I was reading it and I couldn't understand it, and I had to get the acronym book out to work out half of them" (Fr/2/19). Clearly without such resources explaining the language, Karl would have found it very difficult to engage in the activities of the workplace.

Although students in this study were exposed to 'new' language in their work placements, they were able to learn the language and feel more comfortable in their work communities. Grant commented in his second placement that "they've got a lot of technical jargon especially for the different regions of the mast. Certainly for some of the tools we use. Took a while to get used to in fact ... understand it now" (Be/4/12). Jill had a similar experience, noting that "everything is abbreviated, and it takes a while to figure out exactly what people are talking about. But once you've been told once, it pretty much all fits into place" (Le/2/18).

The understanding of this workplace-specific terminology involved the students in learning a new language that was part of the culture of the organisation's enterprise. This language would have developed historically within the workplace community of practice, or its wider industry, and had become a part of the everyday speech of work. In fact, as Nancy discovered, members of that language community can use the terms without realising that others may not understand them, and without consciously relating the term to its origin. She related an incident in which she came across an abbreviation that was new to her, and when she asked a workmate what it meant "they said 'oh that's right you might not know' but then when they thought about it, they had been using it for so long they had almost forgotten themselves" (Wo/2/18).

This example of the abbreviations becoming so much a part of the language that it takes on a meaning of its own demonstrates the powerful effect that language can have within a community of practice. In order to enter that community then, the student on placement would need to learn the language. The students commented that they learnt the language in a variety of ways. Nigel noted that he didn't get taught it, that he learnt the language through experience when "people talk to me

and watching other people talk" (Gr/2/13). Karl and Jeff said they just asked every time some new term came up, whereas James commented "that they gave me books to read, oh you know company manuals and stuff like that, to read just to get used to the language"(Sk/2/20).

The verbal co-construction of language was for many students the key to learning the language of their workplace. From direct instructional practices, to conversations, either direct or overheard, to meetings, this verbal channel was important. This re-emphasises the discussion in Section 6.3.2, in which the students noted the range of purposes of talk that provided them access to learning within their community of practice. In some cases this verbal channel was supported by written documents describing the language, as in James' case above, Karl's mention of the acronym manual, and that of Jeff, who was given a 'dictionary' of forestry terms in his placement.

But non-verbal communication could also feature as new language to be learnt, as Grant discovered in his first placement. Sign language formed a critical part of his communication. Grant was based in a sawmill for his first placement and the noise made speech impossible while working. He experienced some problems with this form of communication in the early days of his placement, commenting that "out in the sawmill a lot of the communication is done in sign language, I lot of which I don't know what's going on" (Be/2/4). Once again, this problem with communication led to difficulties for Grant, noting that his inability to read the signs "usually results in me getting shouted at" (Be/2/4).

After a time in the workplace, Grant learnt what the signs meant and he remarked that towards the end of his placement he felt a lot more comfortable working there. He even noted that he would sometimes see a sign that he had not seen before, wonder what it was and then realise that it meant for him to do something that he had already carried out. This gave him increased confidence in his ability to work there. Learning not only the language, but the cultural way in which it was being used within the workplace, had developed in Grant an intuitive knowing about the use of the language. This enculturation through learning work-specific language also led Grant to feel more accepted by his workmates.

For students in this project, language elements such as jargon, abbreviations and acronyms formed an important part of their learning in the workplace. In many cases learning this new language was critical to the students' understanding of their work and their ability to carry out tasks. In this way it can be clearly conceived of as a tool used by a particular community of practice. This tool allows knowledge and understanding to be distributed across the community (Pea, 1997) and acts to delineate the cultural borders of the enterprise of that community (Cole, 1991).

Learning of language in the placement occurred in social interactions during verbal and written communication. The language of the workplace has its origins in the social relations of the workplace, is grounded historically, and helps shape the culture of the organisation and the industry within its community of use. It may reflect the values, attitudes and behaviours inherent within a community, a subject that is explored more deeply in the following sections. This exploration begins with a look at what students perceived they learnt about the norms of working behaviour in their placements.

6.4.2 Learning about norms of working behaviour in the workplace

This section discusses comments students made regarding the norms of working behaviour of their workmates and how they felt their attitudes and behaviours influenced their perceptions of their community of practice. The students developed perceptions of the values, attitudes and behaviours that varied substantially from workplace to workplace and in some cases left a big impression on them.

What constituted working hard was linked to close monitoring of work outputs for James in his first placement. In this placement, James worked in the service division of a private company. He commented:

> It is reasonably hardworking, everything they do is monitored in real time on the database, so they can't muck around and they take

> quite a bit of pride in saying they finished a job in five minutes you know (Sk/2/11).

James had previously worked for four years in a research institute and had not been exposed to his work being monitored so closely before. His perception was that the close monitoring meant that his workmates were working hard.

The opportunity to participate in authentic activities in a workplace led to learning about working behaviour for students who had little previous employment experience. For example Victor commented:

> I guess the thing that struck me, was how relaxed, well not relaxed, I guess that relaxed is the wrong word. The relaxed mannerisms in which they do things. I mean they are doing things but they are sort of relaxed about it (Ro/2/10).

Victor's placement was in a research and development section of a high-profile company with an international reputation. Prior to working there he said he had little notion of what the people at work would be like and what it would be like to work there (Ro/1/9). His only contact with the company prior to the placement had been the placement interview that he had in order to secure the placement. This had not given him any clear perception of what the company was like to work in. Victor appeared surprised that workers in such a high profile company should appear so relaxed at work.

In contrast another student who had little previous employment experience reported being significantly influenced by his visit to the company for his interview. Rick's placement was in a world-renowned electronics firm and he was impressed by what he saw at his interview: "Pretty scary actually. Because coming into an organisation like this, walking down the corridor, you saw all the awards and you can't help but notice this highly professional place" (Pa/2/6). Rick reported feeling daunted by the visible icons of successful business in his prospective placement company. Prior to his placement Rick expressed concern about whether he would be able to handle the work they would ask him to do, and seeing the awards on the walls heightened his concern that he might not be able to do well enough. In fact after his placement Rick reported that he had felt that he

had performed well in the workplace and had not found the work beyond his abilities (Pa/2/7).

Rick's placement was, like Victor's, in the research and development section of his organisation. He experienced similar relaxed working behaviours in the workplace and made an interesting observation:

> It's hard working, but it's relaxed. It's quite strange because if you looked at it say, some points you could say, no work gets done but if you look at it at other points you would say too much work gets done, so it's a nice balance (Pa/2/4).

When pressed on what he meant about looking and seeing no work getting done, Rick revealed a particular work habit that he observed and subsequently appropriated himself:

> A lot of the time people just sit back at their desk, close their eyes and think about what they are going to deal with. And then they'll do it, so, obviously if you walked into an office with three or four people sitting away from their desks with their eyes closed you would immediately think, you know [no one is working here] but ... I find myself doing it, it's quite a catching habit because you sort of learn to think about what you are going to do before you go and do it (Pa/2/4).

This observation could be interpreted in two ways from a sociocultural perspective. Firstly observation of this way of working could be seen to have mediated Rick's understanding of what it meant to practice in the research and development section of his company. There is an implication of a tacit acceptance that sitting back with your eyes closed means that thinking about work is occurring, and that the practice is a bona fide and useful way of working. Secondly Rogoff (1995) has described the concept of participatory appropriation as individuals changing through involvement in an activity, and therefore becoming prepared for involvement in related activities. Rick's appropriation of this 'habit' from his workplace community was not something that he had been instructed to do. He had observed the practice, rationalised its meaning and come to participate in its use. Rogoff (1995) is careful to distinguish appropriation from acquisition, with the former being contextualised within the meaning of activity, as in Rick's

behavioural change in response to the culture of the community of practice in his placement.

How the physical situation of the workplace could affect the attitudes and behaviours at work was reported as learning by Craig. He was assisting in the setting up of a new website design company, and work was based in the company owner's house. Craig found positive and negative points about the atmosphere created:

> It's good in the fact that it's friendly and relaxed ... the atmosphere there, you know, everyone knows each other and you can play loud music and do what you want within reason. But you've still got to answer to each other but ... it's bad in as much as ... it's treated as not a place of work sometimes ... it's not a business, because it's in a house, it's in a suburb, suburban neighbourhood and it's, everyone's friends and so you get sometimes, other friends dropping in and you get games played and ... it's just sort of forgotten that you've got to focus on business here sometimes (Su/4/4).

The attitudes and behaviours at work had created a tension for Craig between having fun and getting the work done. This experience created an opportunity for Craig to learn about how the attitudes and behaviours within a community of practice can affect the operation of the workplace.

Learning about the norms of working behaviour in research institutes was also reported by students in this study. For two students, Martin and Vanessa, working in research institutes for the first time exposed them to working behaviour that was different to what they had expected. Martin commented that he "thought they did a lot more research than what they do" (Ri/4/10). When asked what he meant by that, he replied:

> I guess it's because like working in [my first placement in a private commercial company], working in a service station, working on a farm, you're just always doing work. You always ... you're physically doing something all the time. Now when I was down there [in the research institute], you could walk into the labs and there's probably six or eight labs there and there may be one

> person there and this can go on for hours and you just ... it just makes you wonder if anyone is actually doing any work (Ri/4/10).

Martin's previous employment experiences, and he had had several, had led him to believe that work meant physically doing something that could be observed. To find workspaces unoccupied for long periods was an unusual work atmosphere for him. He found it very hard to adjust to:

> It is very difficult to determine whether someone is working or not, and it was hard on me because I just ... well whenever I didn't really feel like working I felt awkward about it because I'm used to working ... honest work ... and then seeing all these other ones that were wandering around and looking as though they were doing nothing, yeah, it was a bit unusual (Ri/4/3).

Martin noted later that many of the staff spent a lot of time in their offices, particularly applying for funding " which was something I didn't realise they did" (Ri/4/10). The style of working that Martin was exposed to in this placement led to learning about what it was like to work in research. He noted feelings of awkwardness and dishonesty as the working behaviour clashed with his own ideals of work. This experience led Martin to believe that he wasn't suited to a research career.

In her first research work placement, Vanessa had similar doubts about whether people were working, as she expressed:

> Well some people it seems don't do any work at all! People do things in their lab and then go back to their desks and do things. But it's not like sitting down and hard-out writing, we'll all be chatting away, or walking in and out of everyone's offices, finding out what they are up to, having a moan about something not going right, or talking about things that are going right (Sto/2/4).

Both Martin and Vanessa perceived in their placements working behaviour that was foreign to them and had difficulty adjusting to a new way of working. While their research colleagues may have been spending time thinking, discussing their work or applying for funding, the students' perception was one of unproductive

time, or in Martin's words, a lack of "honest work". The students had gained an understanding of what constituted working in this community of practice.

Finally one student, Joe, commented on the benefit of having done two placements in different research institutes. Early in his second placement he already felt comfortable in the workplace, which he attributed to his first experience in a research placement:

> I think having worked in a [research institute] before helps in working in this [research institute]. Even though they are quite different from each other, I think somehow, I can't quite explain why, it sort of feels a lot more familiar, as though I've been in this working environment before (Mi/4.2/3).

Joe expressed a feeling of familiarity about his new work environment. Although not able to explain why, he had reacted emotionally to his new placement in a positive way. Two months later he noted that there were in fact differences in the working attitudes between his second research placement institution and his first:

> It actually, it might seem a strange thing but it was quite a different culture between here and [my first placement]. Whilst they're both [Crown Research Institutes] and so there's that sense of being a government organisation, at [my first placement institute] at times there was a bit of a pressured, financially pressured environment and people were feeling a bit restricted and a bit harried I suppose sometimes, here there isn't really much of that at all. They know that the money's a little tight but they've still got the money to do the research that they, and they want to do, so that pressure's not as great here and I think perhaps there's a more relaxed attitude at [my second placement institute] than there is at [my first placement institute], not a more lax attitude, just a more relaxed attitude so people feel more freer to do it the way they want to do it (Mi/4.4/10).

Joe had been able to compare his experiences at his two placements and perceived a difference in work attitudes, which he related to the financial pressures on the organisations. He noted that this difference in work attitude appeared to translate into a difference in behaviour in conducting research, stating that in his second placement "people feel more freer to do it the way they want to do it" (Mi/4.4/10).

Joe emphasised that he had learnt how the financial pressures on research institutions could affect their working attitudes and behaviours.

The students in this study have reported that they have learnt about the influence of the attitudes and behaviours exhibited in their workplaces. Learning about how this created an atmosphere at work occurred through observation and participation. Students found that work attitudes and behaviours can be influenced by the physical environment and social interactions at work, as well as factors such as financial pressures. The opportunity to undertake work placements had shown them different ways of working, and allowed comparisons to be made about workplaces.

One aspect of the norms of working behaviour that is constituted in the sociocultural context of the community is the way that people dress at work. A few students reported learning about the dress code at work and this is now briefly discussed.

6.4.3 Learning about the dress code

As Hickson and Pugh (1995) note, clothes are artefacts that are part of the shared values of a culture. In this study learning about the dress code at work was specifically commented on by four students.

Prior to his first placement James was told his placement company had a dress code. This gave him an impression of what the company might be like: "It will be quite formal because there is a dress code, which was quite surprising really. It's a repair group but you still have to dress well. So there will be quite a formal attitude around I think" (Sk/1/8). James linked the idea of having a dress code with a 'formal' atmosphere at work. In fact this was borne out by his experience. He was required to wear a shirt and tie to work, and commented that he experienced a hard-working organisation where the time to complete tasks was monitored and achievement of tasks on time was a matter of pride.

In contrast to James' experience, Donna found that she was surprised by the casual nature of dress at her first work placement, commenting that "I've been surprised at how relaxed people have been, how unworried about time and dress and things like that they are. I would have thought that their dress sense would have been a lot smarter" (Ni/2/8). In making this comment Donna noted that the style of dress gave her an indication of the relaxed nature of the community at work. For both James and Donna, the dress standard appeared to reflect their perception of the work atmosphere, suggesting that dress can be an indicator of workplace culture.

For three of the students who commented on the dress code, it was not something they were told about. Observation of their co-workers was the way they learnt about the code. Kara noted:

> We turned up on the first day in good clothes, and you could just see that everyone was in nice pants, and nice shirt and a tie, and all the women were either in a suit or something like that, so we knew we had to keep a good standard of dress (De/4.1/3).

Kara and her fellow student worker had been able to see the standard of dress required. In her first placement, Kara used the same observational technique to learn about the use of make up at work, reporting that "we used to wear make-up for the first two weeks because we thought it was essential, and no one else did, so we thought 'we don't need to', so we won't. So we stopped" (De/2/11).

In summary, some students in this study reported that they learnt about the dress code in their work placements. The dress code gave them an indication of the role that artefacts such as clothing can play in their learning about the workplace community of practice. In one case the student was directed what to wear, but in all other cases, the students learnt the dress code by observing what their co-workers were wearing, the dress sense mediating their learning of workplace attitudes and behaviours.

A final example to complete this section on learning norms of behaviour in the placement is a brief look at what two students underwent in becoming initiated into their community of practice.

6.4.4 The Ritual of Initiation

A fourth aspect of learning as mediated action was reported by two students in this study, Jeff and Victor, who underwent a type of initiation into the ways of working in their work placements. Initiation has been described as a social ritual in which there is purpose and meaning (La Fontaine, 1985). The purpose is often to provide a test of the uninitiated, and to provide a rite of passage into a new community. The meaning is constituted in the social and cultural history of that community. The two students who reported undergoing a ritual of initiation felt more accepted in their work communities after the event.

In Jeff's case, his second placement working for a forestry contractor began with a tough job:

> When they get new people in they push them, so they took me to this steepest block and really hard terrain, they took me up there to try me out. I was so [tired], I hadn't been in the bush for months, we were running around the bush (Rh/4/5).

Jeff understood that they were testing him out and it was hard on him. He survived and went on to really enjoy his placement in that work community, feeling that he had been accepted by his workmates into the community.

Victor's initiation involved getting an electric shock in his electronics company. He related that "they would try to conspire against me to give me a zap when I first got here. Sort of like an initiation, but I managed it on my own" (Ro/2/7). For Victor it was part of the normal working life of the organisation to get electric shocks, and he was pleased to have outsmarted his co-workers by giving himself a shock before they could. Victor went on to carry out his second placement in the same company and then secured an extended contract with them. Evidently he had passed his rite and had been accepted into the community.

The ritual of initiation is a particular cultural rite of passage that Jeff and Victor learnt about in their work placements. Their perception was that they needed to pass the 'test' in order to be accepted into the community at work. While these 'tests' were overt and obvious to the inductees, it is possible that other students on placement undergo similar initiations, but which are not labeled so. In a sense, initiation can be seen as a metaphor for a cooperative education placement, in which the inductee (student) undergoes a rite of passage into a new community of practice.

6.4.5 Summary of learning as mediated action

If tools, artefacts, attitudes and working behaviours are viewed as defining a particular community culture, then students in this study have reported learning about and through workplace culture in their placements. These reports have included learning the language of the workplace, the norms of working behaviour, the dress code and rituals of initiation.

From a sociocultural viewpoint, the learning of the language of the workplace acknowledges the place of this tool in mediating the student into the distributed knowledge of the community. The learning of workplace language is embedded in its community of practice and constituted through a need to share an understanding of the meaning of tasks to be undertaken.

The students in this study have reported learning mediated by their observation of the values, attitudes and behaviours exhibited in the workplace. This learning shapes students' understanding of what it means to work in their workplace, of factors that affect the atmosphere at work including the physical environment and social interactions. For those students who worked in more than one workplace in their two placements, the possibility existed to make comparisons and understand how these factors were context-dependent. For some students on placement, their learning was mediated by artefacts such as clothing, that provided guidance on how to assimilate into the work community, and processes such as rituals of initiation, that enhanced their social induction into their community of practice.

6.5 Chapter summary

This chapter has provided an analysis of what and how students in this study learnt on placement from a sociocultural perspective. It has highlighted findings of this study that point to the placement setting as one in which learning occurs, and that such learning can be interpreted as socially mediated, situated and participatory activity, and as mediated action.

The students in this study undertook work placements as part of their co-op degrees. During these placements they carried out productive work related to their university studies in an authentic workplace. As such they participated in the day-to-day activities of a community of practice, working alongside practising professionals. This study has found that the students perceived they learnt about working in their placement community.

The students reported learning about and through the social and the cultural community of the workplace. It has become clear through this examination that although the focus may have fallen primarily on either the social or cultural dimensions in this chapter at any point, the two dimensions are intertwined and any separation presented here is artificial and utilitarian. In other words learning as a social process has a cultural dimension, and cultural influences on learning are generally socially mediated.

It has also become clear through this study that student learning through work placements can be viewed as situated and contextualised within a workplace. In this view student learning is bounded by the situated activities in which the students are engaged, developed through their participation in the social interactions of the workplace, and influenced by the culture of the community of practice.

In their learning about the sociocultural setting of the workplace, the students reported finding how different the working environment was to university. Their placements exposed them to new people, new ways of thinking and doing, and

new routines, and some found the transition from the university environment surprising and hard. In particular, the students reported having concerns about social interactions and expectations upon entry into the novel environment of the work placement, which has implications for the preparation of students for undertaking their placements. It would be important for co-op coordinators to recognize possible fears and concerns that students may hold and seek to firstly convince the students that such reactions are normal, and secondly provide reassurance that their fears and concerns will in all probability be allayed very early in their placements

From a sociocultural perspective, students in this study reported learning about work ethics, work relationships, work language, and workplace values, attitudes and behaviours. They reported learning these elements through their immersion in the social and cultural environment of their workplaces. They described how learning occurred by the social mediation of instruction, through which they came to share in the knowledge and practices of the community in which they worked. They noted the impact on their learning of being situated alongside practising professionals, gaining legitimate access to their knowledge and experience, coming to participate in aspects of the community's endeavour. They emphasised the role that talk played in the distribution of knowledge and understanding across the community, and that sometimes there were constraints upon how that knowledge was shared amongst the community, particularly with the students as newcomers. They explained how observation had led to learning about the behaviours that contribute to the culture of the work community, and how some of these behaviours were appropriated during their enculturation into the workplace.

The workplaces that students in this study were being enculturated into were science and technology organisations, in keeping with the areas of study for the students' qualifications. These organisations provided a specific context for the students' learning on placement, and the next chapter looks at what and how students learnt about those contexts.

Chapter 7 Results and Discussion

The significance of context: The science and technology workplace

7.1 Chapter outline

In Chapter 6, an analysis of student reports of their learning in work placements emphasised the situatedness of that learning within the workplace context. Context in this thesis is seen as a socially, culturally and historically determined community of practice, in which members of the community work towards the goals of their community. This chapter explores what the co-op students in this study felt they learnt about the practice of science and technology in the communities of practice of their work placements. The placements situated the students in the context of the workplace, in which one goal is to allow the students to undertake work that has relevance to the student's study programme, in this case, science and technology. These placements were intended to complement their university studies.

This chapter begins with an analysis of what students reported learning about the specific practice of science and technology in one of three contexts in which they were placed, namely private commercial/manufacturing companies, public research institutes or local government organisations. The following sections examine what students noted learning about doing science and technology, and being scientists and technologists, in their placements, beginning with discussion from prior to the placements about their perceptions of science and technology and how it is practised. Their experiences of the actual practice of science and technology are then discussed, with a focus on the knowledge and skills they felt they gained.

7.2 Three science and technology workplace contexts

In the BSc(Tech) programme the placement organisations can be broadly categorised into three main groups according to their main business focus: private

commercial/manufacturing companies, public research institutes and local government organisations in the form of city, district and regional councils. This section provides an analysis of what students reported learning in three science and technology contexts. For the purposes of this study, and particularly the discussion in this section, the distinction between the three contexts is based on the main business focus of the organisation. It is recognised that in some cases the students may have been involved in activities other than the main business focus, for example commercial activities in a research organisation, or research in a local government organisation.

Within the study, the 22 students undertook 41 placements between them (three students didn't undertake a second placement due to a change of study programme). Of the 41 placements 25 (61%) were in private commercial/manufacturing companies, 10 (24%) were in public research institutes and 6 (15%) were in local government organisations. All of these placements were offered to the students on the basis that they afforded opportunities to complement their science and technology education at the university.

7.2.1 Private commercial/manufacturing companies

Students in this study placed in private commercial/manufacturing companies reported learning about career opportunities, the international dimension of the sector, and the pressures of the commercial world. As noted in Section 1.5, the majority of private commercial/manufacturing companies in New Zealand are small to medium-sized on a world scale (i.e. < 500 employees) and have limited research and development operations. Typically BSc(Tech) placement students have been placed in technical positions for quality control and small development projects. Within the 25 placements in the private commercial sector undertaken by students in the study, there were placements in the dairy, forestry, electronics, plastics, information technology, automotive and energy industry. Many of the students noted that their placement company was one of the few in their industry and was focused heavily on the export market.

The unique nature of his science and technology workplace was commented on by Karl. After three months working in an automotive parts manufacturing plant, he had come to this understanding:

> It's very, very specialised. For a few of the guys who are out in the plant, who are up a level, like the toolmakers and the specialists for the die cast machines, there is nowhere else in New Zealand for them, besides [one other company]. There is a couple of small aluminium plants around that do one-off things, like Cheviot wheels and things. But they're only little plants, with only one die cast machine compared to twelve that we're going to have. Very specialised (Fr/2/13).

Karl's placement was subsequently extended out to over twelve months in one continuous period. This gave him the opportunity to get a long exposure to the industry and his career opportunities within it, and he learnt about the difficulties that he might face:

> It's a unique industry and I hate to be blunt, but I think you would have to watch that you don't get stuck here, because you could get stuck here for the rest of your life. Because there is nothing, if you didn't want to leave New Zealand (NZ), 'cause there is nothing else like it in NZ anyway (Fr/3/7).

In the late 1990s and early 21st century many skilled and qualified people have left New Zealand for what they perceive to be better opportunities overseas. After this placement experience Karl felt that if he wanted to progress his career in that industry he would have to follow the trend because of the lack of opportunities in New Zealand. Towards the end of his degree he was actively looking for jobs in Australia.

The international dimension of the commercial world was also noted by Karl in his placement. He learnt that such companies needed to be cognizant of world markets:

> Everything is international, you have to look at the international picture. Like basically we have to study the car market in America, we have to look at the American economy. Because if they're going down, we don't have to make as many wheels and that's less

> jobs. Whereas in a national company that's only supplying NZ, you only have to mainly look at the NZ economy and have a little look at the rest of the world (Fr/2/23).

Karl experienced the fluctuations of the international market first-hand. During his time on placement, the company went through a rapid expansion to meet increased orders, a rapid mechanization that resulted in job losses and uncertainty amongst staff about their futures, and a complete restructuring of management. These changes left an impression on Karl, who noted consequent changes in the cultural and social atmosphere at work, commenting that at times "the plant lost its direction and control"(Fr/3/5) and people "were worried about their jobs" (Fr/2/11). This type of experience for a student on placement is an introduction to the strategies used in the commercial workplace. As Karl noted, these strategies have an impact on the social interactions at work and lead to learning about how people react under those circumstances, learning which could not be replicated in a classroom environment. This finding has implications for preparation and welfare of students on placement, who may find themselves in an unsettled workplace.

The pressure of the commercial world that affected people's emotions at work was also experienced by Jill in her first placement. Jill was working in a dairy factory, when workmates' jobs came under threat due to a low supply of milk:

> The biggest thing I've noticed this year is the stress put on everyone with the weather affecting the milk rate. No milk, no products, no products, no money. So that's the biggest thing, there have been plants shut down all over the place, and people have been losing their jobs. It's been very prominent in people's conversations (Le/2/8).

The dairy industry is one of the biggest in New Zealand and Jill had a career goal of getting employment in the industry upon graduation. This opportunity to see how the seasonal climate could affect the business, and how the workers and the company coped with that influence allowed Jill to learn about the impact the milk supply could have. She noted how the grapevine spread information by rumour around the factory and that worker morale was affected by the rumours. Through her involvement with her workmates and their conversations Jill came to

understand what working in such an environment means to those whose jobs are threatened.

The drive for production was a further aspect of the pressures of the commercial world reported as learning in their placements by students in this study. For example, Rick noted how he felt the world of business differed from the university world:

> Just seeing how the world does business. This is real, really amazing, well, as opposed to everything at university, if you maybe have to do a project and it didn't quite work, try it for a few hours and if it didn't work you could just basically give up. It doesn't work like that here. Stuff is needed, got to go out there, it's got to be sold, people have to pay money for it. It's how an industry works. (Pa/2/15)

Rick's perception was that what he had worked on at university wasn't 'real', that the concept of production was different in the workplace to the university. In this view it would seem impossible to convey the feeling of the 'real world' to students by getting them to do a university project, such as an assignment or laboratory tasks. For Rick the meaning of the commercial world was entirely different from the university world, with the end goals of doing tasks being fundamentally different. This emphasises a different focus of the two worlds, and implies that the placement may hold different meaning for students to their university courses.

A second example of the commercial pressure of production was provided by Jill. In her second placement, in a different dairy factory to the first, she identified some good and some bad aspects of that focus:

> It's good in the sense that you're forever striving for goals and you have definite standards and stuff that you have to meet and everything. It's really good, you can't really slack off because you have got to have so many tonnes done every day, but it's also bad in the sense that the company is always striving for the bigger, not profit margin, but they're always trying to cut costs in manufacturing, so they can increase the money that they earn. And it just seems to me that it's almost gone a bit too far these days, where you can't keep making the bottom line better and better and

> better, because you start losing out on the people and it will all fall over in the end (Le/4.5/6).

Being in the commercial environment Jill had perceived that production was the most important part of the company culture. She had come to the conclusion after two placements in production companies that the drive for better production could be unhealthy. In her second placement, when she made these comments, the plant she was working at had recently been restructured, many managers had lost their jobs and some areas of the plant had been shut down. Jill reported that this had severely affected staff morale, indicating that she had learnt about the meaning of the commercial production environment through social interactions in her placement. Jill's experiences are discussed in more detail in Section 9.3.

A final aspect of learning about the pressures of the commercial world, commented on by Rick, was the commercialisation process. His first placement was in an electronics company, specialising in weighing devices, which serviced both the domestic and commercial market. He was involved in software testing for products and could see how the factors that led to commercialisation of a product fitted together:

> I have a concept of budgets and timing and things like that. Things that before I used to think, 'I'll just design something and who cares how much it costs and we can get it to market inside a month', sort of thing. Now I know how long it actually takes and how much preparation and planning that it goes through (Pa/3/1).

Rick felt the experience he had of participating in the process of product development had changed his view of that process. His prior conception of commercialisation had been shown to be incorrect, a change in understanding which he saw as being very valuable to him.

In summary working in commercial manufacturing communities of practice had given the students in this study some understanding of the career opportunities within New Zealand manufacturing industry and how specialized they are, the ramifications of an international/export focus, and the pressures of the commercial workplace. They had noted how changes in their workplaces due to commercial

pressures affected the emotions and social interactions of their workmates, influencing their own understanding of those changes. They also reported learning the role production plays in a commercial/manufacturing company.

7.2.2 Public research institutes

Students in this study placed in a public research institute reported learning about the process of doing research, and the effort that goes into securing funding for research in the public sector. Science and technology research in New Zealand is largely carried out by publicly-funded research institutes. As noted in Section 1.5, a low level of privately-funded research (0.26% of GDP) is carried out in comparison to other OECD countries, and as a consequence there are few private research institutions in which a student could be placed for work experience. In the public sector, research is carried out predominantly by the nine Crown Research Institutes (CRIs) and the eight universities. Whilst the CRIs gain much of their funding through a competitive bidding process to government funds, they are expected to acquire increasing levels of private funding. This funding requirement has caused many CRIs to adopt a more commercial model of operation in recent years. In this study there were nine student placements in CRIs and one in a university research group. These placements were at the technical level and all involved the students in research projects, although some students also contributed to routine commercial work being conducted by the organisation.

The amount of work that went into the process of research was commented on by every student (10/22) who was placed in a public research environment. For example, in his first placement in an agricultural research institute, Duncan noted that "there is so much technical work to be done to produce a final result. It is definitely worthwhile to have research done for farming, it's just a shame that it takes so long"(Ho/2/5). Mike came to a similar conclusion after his first research placement:

> As far as being a research scientist goes, it's pretty much 95 per cent donkey work and five per cent results. It seems that research is really quite frustrating when things go wrong, and things like that. There's a, like there's no guarantee that a trial when it starts

> will give you any decent results and stuff like that. Like, there's one guy that got some cattle breaking into his plots and stuff like that and chewing it off and you know, just terrible things like that, you never know what's going to happen (Mc/2/20).

The research placement experience had given Duncan and Mike a perspective on scientific research which they had not seen before. Up to that point in their education, the research they had done at the university was based around small knowledge-gathering exercises. These had not prepared the students for the experience of participating in experimentally-based research projects in the workplace, so that the opportunity to become involved in such projects in the workplace led to learning that was specific to the placement. Through their participation in a research community they had gained some understanding of the research process.

The unpredictability and frustrating nature of science research was also described by Mike in his first placement. Evidently the critical incident with the cattle had left an impression on his perception of the likely outcomes of research, and he added later that although he could "see how important research is"(Mc/2/20), he felt that he was more suited to applications of science rather than conducting research. The experience of being involved in a research environment had given Mike a perception of what being a researcher could be like, and caused him to reconsider his career direction.

The frustration of the research process was also commented on by Vanessa, when she described dealing with equipment in the field. She related:

> Working out in the field is an experience. Some days everything works well equipment-wise. Water is flowing out of the permeameters [devices for measuring the permeability of fluid through a substrate such as soil] at a constant rate according to pressure. Other days we are not so fortunate. Water will be flowing too quickly. Holes are found in the mesh, soil surface isn't flat. One day we had no idea what was wrong. It was frustrating. We just had to spend the following day in the lab, pulling apart the permeameters and building them again, testing for problems. It was trial and error (Sto/J1/3).

Vanessa had built the permeameters with a colleague for the specific purpose of the research project. As research like this seldom allows the use of an off-the-shelf model, she found herself developing skills in carpentry and plumbing which she had never thought she would need in science. This experience was quite different to that which Vanessa had encountered in her university practical work. In that environment equipment was standard and readily available and if a problem occurred with it, a technical person repaired or replaced it. The emphasis was on interpreting the result of the task, rather than on the process of getting the task done. In the workplace working as a research technician, she found she was responsible more for getting the task done rather than interpreting the results of the task, which was more the preserve of the scientist. This difference led Vanessa to think about the roles of the scientist and technician in the research environment (see also Section 6.4.3.2).

Learning what it means to be a researcher in the research process was also commented on by two students in this study. In Joe's case he articulated the process he went through in developing into a science researcher through his two placements in science research (see Section 9.2 for a fuller analysis). But Martin's perception was somewhat different. He noted that prior to his research placement he felt he had "no idea of how a researcher is supposed to think or what we were supposed to do and stuff" (Ri/4/8). At that stage of his career Martin had had several part-time jobs and a previous three-month placement. However, he had had no previous work in a research institute and the environment of the researcher was foreign to him. His concern with "how to think" indicates Martin's perception that researchers might think differently, and an opportunity to work alongside them may give him an insight into how they think and why they act. In fact although he felt he adapted easily to the research work environment, Martin perceived that he had not reached an understanding of how a researcher thinks in his three-month placement. Martin was able to describe how he carried out the research that was undertaken but two questions arise as to why he felt he had not reached an understanding of how researchers think.

Firstly it is possible that the three-month period was not long enough for him to be enculturated sufficiently into the world of the researcher to understand their

thinking processes. In contrast Joe felt that his six months of research work experience had given him a very clear view of how to think and act like a researcher (see Section 9.2). Secondly there is the question of whether the supervising researcher had involved Martin in the process of research decision-making, or had rather used him as a technician to whom bald instructions could be given without explanation. In answer to this second question, Martin described how he and his supervisor would discuss the experiments to be done and their outcomes, so it is at least likely that Martin would have been able to observe a researcher during his thinking process. It is possible that the process was not as overt as to allow Martin to understand it. Or perhaps Martin had understood more than he gave himself credit for and could not articulate it, gaining a form of tacit knowledge regarding the research thought process.

The other major area of the research environment that students reported learning about was funding. Joe's comment was typical:

> I suppose I've learnt that the scientist working here has to be very conscious of finances and they are put under a certain amount of pressure to manage things and to get results. And that is problematic sometimes that they have to make a profit (Mi/2/17).

After just three months working as a science technician in a research institute, Joe had learnt about the role funding played in a science researcher's life. This was evident to him in the conversations that he had with the scientists and technical staff at work, and seemed to him to pervade all the decisions that were made about the direction of the research. He noted the problem of making profits through science research.

The influence that funding has on the research workplace was also noted by Vanessa. After the first of her research placements in a CRI she commented:

> It's a 'dog eat dog' world out there. If you don't make good, sound business plans or meticulous plans for research bids, or you have poor morale/teamwork in your organisation, you are going to miss out. You need funding from the government through the PGSF [Public Good Science Fund]. Scientific research costs money (Sto/J1/6).

Vanessa noted the competitive nature of research funding and the need for research institutes to take a business-like approach to getting money for research. She noted the amount of time that scientists would spend trying to obtain funding. Martin echoed this theme claiming that he had not realised that researchers had to spend so much of their time looking for money:

> A lot of them are writing up proposals to get the money, funding and so forth, so it takes a lot of their time just to try and make a persuasive argument for getting the funding. And that's one side of researching that I didn't know they did. I thought it was just straightforward. That they worked for this organisation, they went and did the research, they came up with the conclusions, wrote the paper, gave the technology away to whoever (Ri/4/10).

Martin's prior view of publicly-funded science and technology was probably true of New Zealand ten years ago. However the introduction of a more commercial model has led to competitive bidding, greater protection of intellectual property and a commercial focus on saleable products. From first-hand observation, Martin had noted what this change of environment meant for people in the workplace, and had altered his conception of the type of work that was conducted.

In concert with the pressures of obtaining government funding in the CRIs has been a rise in the amount of commercial work conducted in an effort to boost income for doing research. This was mentioned by some of the students, when they talked of what they had learnt in their research institute placements. As Nancy found on her first placement in a CRI:

> They do a lot of commercial work, far more than I thought, in terms of analysing soils and waters for councils. But being here has opened my eyes up. This is the only way that you operate because commercial work brings in money that you can use in other areas for research. Research takes a long time and it's always hard to get funding, so they try to spread it around (Wo/2/6).

Nancy had also seen the time and effort required to undertake research in her placement, and had concluded that commercial work was necessary for funding.

She felt the need to do commercial work led in her eyes to a delineation within the staff, as she wrote in her journal:

> There are two distinct groups of work/people. Contract/commercial work and research. Commercial work appears to take priority over other research, hence my being drafted into doing tasks for other people who require work to be done urgently. Possible reason for this being that short contracted work is economical [i.e., maintains cashflow] while research funding requires bidding and longer time spans (Wo/J1/4).

Nancy's perception from her placement experience was that the commercial work was a means to an end for the organisation, and that the organisation would do what was necessary to operate in a commercial environment in order to fund their research. Nancy's placement gave her the opportunity to work with both the commercial and research groups and she was able to see differences in the way they worked and the pressures they were under.

In summary working in a research institute context had given the students the chance to learn that the research process can be time-consuming and frustrating. The students expressed different perceptions about learning about whether they learnt what it is like to think and act like a researcher. An aspect of the research environment commented on by a number of students was the influence of funding, whether it be writing proposals to get it, or how much is used in carrying out a research project, or the amount of commercial work now carried out by research institutes in order to fund their own research. The exposure of the students to these issues in the workplace had clearly made an impact on their understanding of the research institute context.

7.2.3 Local government organisations

Placements in local government organisations led students in this study to report learning about resource management and the relationship between the organization and its community. New Zealand local government organisations are known as councils, overseen by elected councillors who make decisions regarding the effective administration of cities, districts and regions (provinces). The city

and district councils are mostly concerned with municipal affairs and planning of urban development, and as such carry out little work in science and technology. The regional councils have a mandate to monitor and care for the environment in their regions according to the New Zealand Resource Management Act (RMA) (1991). This Act is based on sustainable practices and requires that regional councils collect scientific data on which to base planning decisions. These councils carry out significant work in environmental science.

Three students carried out both of their placements in regional councils. Kathy and Kara spent their first placement together in one council, and then were together again in a different council for their second placement. Donna spent both her placements in the same council and was subsequently successful in securing a permanent position in the council.

Learning about the importance of the RMA in the work of the council in which she was placed was highlighted by Donna. After almost a total of a year working for a regional council, Donna felt the purpose of the council was "to process resource consents in accordance with the Resource Management Act, and a lot is to do with research. And providing the public with data that they are interested in" (Ni/4/8). Donna had experienced the use of the RMA to guide the council's decisions, and the requirement to process consents for resource use within the region for landowners and businesses. She had also noted the importance of collecting and distributing data and dealing with the public. Her placement work involved collecting data for databases on the region's groundwater. This involved travelling around the region, taking samples and talking with the public about the use of groundwater.

Understanding the regional council's relationship with the public was particularly significant for Kathy and Kara in their placements. With the council's mandate to ensure that the region's environment is looked after in a sustainable way, council staff are often placed in a position of confrontation with landowners and developers. Kara declared that you would have to be a 'people person' to work for a council (De/4.2/14). Kathy made the following observation:

> If you're dealing with the public, just from listening to people, especially the consent officers who have a lot of trouble with angry people, about not being given consents, or angry about this, angry about that and you have to be able to look beyond that and see what you're doing has a purpose and that's why you've got to teach. A lot of it at the council I think is teaching people, in a way, you know. (Ba/4.4/11)

From her two experiences in councils, Kathy had concluded that councils have a role to play in educating the public in resource use, and had learnt about the difficulties that they experienced in this role through her participation in the social interactions of the workplace. Kara had also noted these difficulties when she was teased about the council's work by a farming family she knew personally (De/4.3/9). This gave her an insight into the two sides of the issues behind resource use.

In summary working in a regional council context had given three students knowledge about the work a regional council does and the significance of the council's relationship with their community. It had also provided an insight into the working environment that proved attractive enough to convert one placement student into a permanent employee.

7.2.4 Summary of learning in three science and technology contexts

The BSc(Tech) placement programme provided students in this study with the opportunity to work in one of three science and technology contexts: private commercial/manufacturing companies, public research institutes and local government organisations. In this study, students in placements in each of these contexts learnt about aspects of what it was like to work in those contexts.

The students perceived that they learnt some key facets that underpinned their placement context. They came to understand some of the parameters within which companies operate such as specialisation and international focus, the funding and costs of research and the organisation's relationship with the public. From a sociocultural perspective, the students experienced how the financial position of the organisation was an influence in the workplace, and how concerns about

funding affect the morale at work. They noted how they learnt about the pressures of the commercial workplace through their participation in their placements, through hearing conversations, attending meetings and reading company documents. Some of these pressures led to job insecurity and restructuring in the workplace, which had impacts on the social interactions in their communities at work. The possibility of encountering these realities has implications for preparation of co-op students before entering the placement. Students may need to be made aware of changes that can occur in the workplace, how they should react to those changes and understand their meanings. Students who find themselves faced with these situations may be adversely affected and should be offered support in the placement.

The next section provides an analysis of what students reported learning about science and technology, and about being scientists and technologists, in their placements.

7.3 Learning about science and technology in the placement

One of the aims of this study was to examine what the students felt they learnt about science and technology through completing their work placements. It was important to determine whether this discipline-specific learning was complementing the students' learning of the discipline at university, and whether it leads to the students constructing meaning about the practice of science and technology within the two sociocultural settings (Bell & Cowie, 2001; Hennessy, 1993).

All students in the study had completed one year full-time study at the University of Waikato, studying science subjects, before entering the work placement programme. It is reasonable to assume from this background information about the students in this study that they were interested in science and technology. All students were majoring in some aspect of science and technology. The students ascribed their interest in science and technology to a number of factors: the science they had done at school (9/22 participants); particular teachers who motivated them (6/22); their family and home environment (7/22); and their own

interest which could not be attributed to any one factor (10/22). No dominant pattern emerged from this study as to the motivation of students to study science at tertiary level. Most students had studied science at school and had carried on to study science at university. Three students, Karl, Christine and James, had been out of school for 3-5 years before coming to university and two of those, Christine and James, had worked in some form of scientific workplace during that time.

All the students commented before entering their first placement that they hoped to find out what it was like to work in science and technology workplaces during their placements. This section reports on what and how they did learn about science and technology, beginning with the students' prior conceptions about the practice of science and technology.

7.3.1 Students' perceptions about science and scientists

The perceptions that students in this study held about science and scientists prior to their first placement is discussed in this first section. Science has been described earlier (see Section 3.5.1) as both a body of knowledge and a set of practices that are used to extend that knowledge. When asked to define what science was, most students found it necessary to think about the questions for some time, and then gave their answers hesitantly. Joanne felt science was about "understanding how things are. I'm not quite sure" (Ev/1/8). Lucy stated that "I think science is about trying to understand, understand what goes on in, kind of ... natural processes. Trying to understand how they happen and why they happen" (Str/1/8). This emphasis on understanding why processes work and why they happen was the prevalent view amongst the students about the nature of science, with 17 out of 22 students giving this answer. This view sees science as a process for gaining understanding about the world around us.

A smaller number of the students (5/22) focussed exclusively on a body of knowledge or the discovery of new things as their definition of science. For example, Duncan commented that "I guess it is the body of knowledge, associated with um, I guess yeah, a living world" (Ho/1/9).

A few of the students (3/22) saw science as including the application of knowledge gained, particularly for improvement of our lives, as Craig said "it is like understanding what makes things tick, how things work, how you can improve things by our own efforts" (Su/1/9). These students felt the application of science was important to them and felt that they wouldn't want to be involved in science just for the sake of it. They wanted their science to accrue some benefit for people.

The students in this study were also asked about their perceptions of what they thought scientists did, prior to undertaking their first placements. It was of interest to understand what perceptions the students might hold about the profession that they were studying towards before they had had experienced it. Only two of the students in this study had worked in science prior to their first placement, and the remainder had been exposed to science predominantly at school and university.

The students who had previously worked in science held views of a scientist that differed slightly from those who had not. Christine had worked in a medical microbiology laboratory, and James in a research institute as a technician, and they described scientists as attempting to learn about natural processes and solve problems. They were the only students in this study who mentioned problem-solving as a part of the role of a scientist and it is possible that their prior science work experience had contributed to this view. Their opportunity to work alongside scientists engaged in solving problems may have led them to this understanding.

Of the remaining 20 students in the study, 15 (75%) gave a scientist's role as doing research or carrying out experiments and one specifically mentioned observing patterns. Mike described the scientific method in his explanation of what scientists do:

> Like you would have a set method to go by I guess, you'd have an aim to give a hypothesis for whatever you thought the effects of whatever you were looking at were going to be. You'd have a set experimental method that you would be going through, probably have controls. A set way of measuring the results (Mc/1/6).

This view of science work echoes what Mike would have been exposed to in learning about science at school and university. Students are taught how to use scientific methods in their science practical sessions and Mike held a clear view of how to use them. Interestingly his use of the word "set" when describing the method and the way of measuring results indicates a predictable and known entity and leaves no indication of uncertainty. This emphasis may have a root in the manner in which Mike had learnt science in the classroom, through being given already known methods and ways of measuring results. This view ignores the development of methods and the unpredictability of science. As discussed earlier (see Section 7.2.2), in his first placement in a research institute, Mike reported his surprise in learning about the amount of development work that went into scientific research in order to get results. This indicated a change in Mike's thinking through his placement experience about what it meant to do science.

When asked about their views of a scientist some students (3/22) revealed a view of scientists as people in white coats working in a laboratory all day. For example Victor commented that "I guess when you say science, you think scientists, and you think the classic person in a white coat in a lab" (Ro/1/7). This somewhat stereotypical view was abhorrent to Victor. He was studying electronics and saw himself moving away from science towards technology. Similarly, Grant professed that he "would prefer myself not to be pictured as a scientist", stating that he did not want to be seen as a "mad professor" cooped up in a laboratory all day, sentiments that were also expressed during a study of chemistry tertiary students (Dalgety, Coll, & Jones, 2001). Grant also wanted to work in technology and evidently viewed the type of person who worked in technology as quite different to the stereotypical view of the 'mad scientist'. In their placements neither Victor nor Grant worked alongside people in white coats, and this may have contributed to their reports that they could see no science in their placements (Be/2/11, Ro/4/15).

Finally, two students, Kara and Sally, were unable to provide a clear description of what a scientist does. One of these students had an interest in environmental management and the other was studying forestry. Both of these students had completed a number of science courses at university with practical and field trip

components. It appears that these experiences had left them unable to bring readily to mind a concept of what a scientist does in scientific practice.

In summary, prior to their first work placement, the students in this study mainly saw science as understanding how processes work and why they happen. Some students associated science solely with a body of knowledge. Most students thought that scientists do science by research, experimentation and observation, and as noted earlier in this chapter were surprised in their placements by the complexity and unpredictability of science research. The views held by students about science work reflected their emphasis on the research environment and indicated less consideration of scientific work carried out in non-research settings such as quality control and monitoring. It is possible that the students had no conception of the science that may occur in those environments prior to their placements.

This background on the student perceptions of science and scientists is provided in order to demonstrate their thinking prior to going into the workplace. This thinking can be contrasted with what the students learnt about doing science in their work placements, as is discussed shortly.

7.3.2 Students' perceptions about technology and technologists

This section focuses on the perceptions that students in this study held about technology and technologists prior to their first placement. It is only in recent times that science and technology have begun to be viewed as separate entities (Layton, 1988). Recent attempts to define technology have led to a concept of artefacts, techniques, improvement and systems (Gardner, 1995) and as a discipline concerned with solving practical problems (Driver et al., 1996). As students in this study were entering workplaces in which they would almost certainly encounter some aspect of technology, it was of interest to understand their perceptions of what technology is, and what it means to work in technology, prior to their first work placements.

As with defining science, students in this study had some difficulty in defining technology. It is likely that they were all familiar with the common usage of the term to describe artefacts such as computers and gadgets, but only a small number (2/22) responded that technology consisted of artefacts.

Many more students (10/22) perceived technology as a process of making things. Victor's view was typical of this group and he stated that "I guess technology is using the existing science to make things" (Ro/1/7). In this comment Victor also expresses the view that technology is an application of science, a point made by 10 out of 22 of the students in the study. In other words prior to their first work placement in science and technology, nearly half of the students perceived that science led to technology. This is at odds with some modern thinkers about technology who believe that the discipline is not just an application of science (Burns, 1990; Gardner, 1995; Layton, 1988), but that it should be seen a separate discipline altogether.

Some students in this study regarded technology as synonymous with improvement in general (4/22), and with better ways of doing things (4/22), a concept that Gardner (1995) reports as being in common usage, and has been found in diverse societies (Sade & Coll, in press). Craig commented that technology is "improving ...what we use in everyday life, to make things easier for us, I guess" (Su/1/9). Only one student, Nancy, mentioned problem solving as an element of technology. She noted that "technology is ... using ideas, making them into things to suit a specific purpose, to solve a problem of some sort" (Wo/1/6). One student was unable to give any definition of what technology is.

Giving a description of what a technologist does was even more difficult for students in this study prior to their first placement. Nearly a third of the respondents (7/22) were unable to give any description. For example, Duncan's response was "I have got a friend who's doing technology and yeah, um, I don't know to be specific" (Ho/1/9). Despite having a link to someone studying technology, Duncan had been unable to form an impression of what his friend might do in his career. At this stage in their careers few of the students had studied subjects labelled as technology at university, none had studied subjects

labelled as technology at school (at this time technology as a subject was only just being introduced to school curricula), and perhaps only one or two students had been exposed to anyone working as a technologist in a workplace. So this apparent ignorance of what a technologist does is perhaps not surprising.

Of those students who proffered a response, 8 out of 22 thought technologists made useful products and 7 out of 22 thought they designed better processes. For example, Jill thought a technologist was someone who "comes up with processes or a gadget that will give someone a benefit that they think they need or want"(Le/1/7). The students were able to describe the final outcome of the work, such as a new process or gadget, but none explicitly described the process that a technologist might go through to carry out this work. This is in contrast to clearer descriptions of the scientific method given by the students when describing what a scientist did, as noted in the previous section.

Finally, two of the students thought that technologists would be applying research that other people (by implication, scientists) had come up with. As a technologist, Martin felt that "I would be out using someone else's research and using my own applications of that" (Ri/1/6). For these students, the starting point for technology was someone else's research, that could then be applied. At no point in any of the discussions with students about technology, did any of the students describe a problem to be solved as the starting point for technology, although this could be implied from comments students made about technology being about finding new or better ways of doing things, or making new or better products.

In summary prior to their first work placement, the students in this study mainly saw technology as a process of making things and an application of science, with an emphasis on improvement and finding better ways of doing things. These views translated into conceptions of what a technologist does, with perceived roles being the making of useful products and designing better processes. These conceptions broadly reflect notions of technology as described in the literature, with the exception that students' views of technology as an application of science are not accepted by some writers. From this analysis it would be reasonable to

conclude that student conceptions of technology and technologists in this study were not as clear as those of science and scientists.

This background on the student perceptions of technology and technologists is provided in order to demonstrate the students' thinking, largely constructed in the university context and prior to going into the workplace. This thinking can be contrasted with what the students learnt about doing technology in their work placements, which is discussed in the next section.

7.3.3 Learning about the practice of science and technology in the placement

Co-op programmes aim to give students the opportunity to complement their learning in the classroom with learning in the workplace within their area of study (that such learning is different in each context is explored more deeply in the next chapter). The students in this study undertook either one or two placements in workplaces in which science and technology is carried out. This gave the students an opportunity to work alongside scientists and/or technologists who are practicing in a field of endeavour that is close to the student's interests and courses at university. As such it was possible that students might learn about an aspect of science and/or technology through their placements, which might not be able to be learnt in the university context. This section describes their perceptions of that learning.

What emerged from an analysis of the students' experiences was the highly contextualised nature of their learning, and the impact of the situation in which the student was placed on their learning. In other words, a student may have been placed into an organisation in which technological development was a cornerstone of the work, yet the student may not have come into direct contact with the development process. On the other hand, a student may have been placed into a research institute and worked alongside a scientist carrying out research. The experiences and potential learning opportunities for these two students may be quite different. To illustrate this three short case studies are presented, which highlight particular outcomes, followed by a discussion of other learning outcomes.

7.3.3.1 The Case of Grant

Grant was a technology major interested in forestry and materials. His first placement was working as a shed-hand in a sawmill. In this job he was responsible for stacking and wrapping sawn timber for shipping. The mill was a production site in which little research and development was carried out. His role was essentially one of manual labour in which he worked alongside people who had little or no tertiary background, and no qualifications in science or technology. After his first placement, he wrote in his journal that "as I didn't come into contact with any scientists or technologists, I was unable to learn anything about them" (Be/J1/3). Grant felt his learning had been stifled by his lack of opportunity to have contact with practicing professionals. He had been unable to apply any of his knowledge and skills from university to his placement, and felt that, although he had gained some knowledge about the timber-milling industry, it did not fit well with his notion of working in technology. Grant rated this placement as unsuccessful. At his placement interview with the employer, he had been promised work on a development project as part of the placement. However, due to a change in circumstances and production deadline pressure, he was never given that opportunity. Although Grant felt that he learnt about the timber industry as a career and how to work with people, he was dissatisfied with the experience as he had been unable to apply or significantly extend his knowledge and skills in science and technology.

In his second placement, the company he worked for was involved in producing state-of-the-art materials for components for yachts. In theory this would have afforded Grant better opportunities, to observe the research and development of new materials and be part of a technological process. However in this placement too, Grant found himself on the production line. He noted that the company had a team of top designers, but he was unable to see them in action due to circumstances beyond his control, although again he had been promised that the placement would allow some interaction. At the end of his second placement, and a total of 12 months in the workplace, Grant felt as though he had learnt nothing about working in science and technology, as he noted "I haven't really worked

with science and technology in any of them ... haven't really been involved in anything too technical" (Be/4/16). Although Grant had worked with materials and learnt a little about their mechanical behaviour, he felt his role in production left him unable to capitalize on his learning.

From his point of view Grant's placements had not contributed to his learning about science and technology. Prior to his placements Grant had seen technology as developing new products, and he felt that he had not been involved in anything like that in his placements. Although he was aware in his second placement that technological developments were being worked on in the company, his placement situation had not given him access to that area of the company. In his opinion these placement experiences had failed to show him what it might be like to have a career in science and technology. As far as Grant was concerned the only career outcome from his placements was to convince him of the need to do a masters degree so that he could get beyond the factory floor and work as a technologist.

7.3.3.2 The Case of Karl

Karl was a technology major interested in material science. His first placement was with a car wheel manufacturer and although initially taken on for three months, the placement was eventually extended to a total of 14 months. The company environment was one of high-pressure manufacture for the export market and Karl worked in the management team on quality control project work, and he also did some supervision on the production line. From these perspectives Karl felt that technology was being practiced in his workplace, as he explained how new wheel models would be made of magnesium instead of aluminium:

> That's technology. How are they going to make magnesium wheels, you can't machine them very fast because it explodes. Well you know what magnesium does? If it gets too hot. You don't want to know how fast they machine those aluminium wheels and how much heat's involved. So yeah we'll be machining very slowly. I don't khow they can cast them, that's what I want to know. But there are processes out there for casting (Fr/2/21).

In his placement Karl was fully involved in the process of producing wheels and understood the problems that needed to be solved. He felt his experience had taught him what it was like to work as a technologist:

> It is actually a crash course process. Especially the aluminium technology. The ultimate thing is you can draw anything on paper but you've got to trial it all. It's like the new style wheels they are making at the moment, one of them is going to be scrapped because you can't cast it. You can't physically make it, the design (Fr/2/21).

Through his work and observing the trialling process in the workplace, Karl had seen first-hand a gap between design and reality. Prior to his placement he hadn't discussed this issue as being part of the role of the technologist, and it is likely that without the direct experience of seeing such a gap before, he might not have realised its significance. At university Karl had been exposed to many design projects and within his courses he had participated in the process of design. But he had not had the opportunity to experience if designs worked in the manufacturing workplace. His placement had given him the opportunity to be a part of the whole process and experience the problems associated with it.

Karl also felt that he had learnt more about the interaction between science and technology in the workplace:

> Obviously there is the science behind magnesium, they have found that out. And same with aluminium, you need to know the melting point and boiling points. The science side has already been done, they are just using the technology side to develop it from what someone else's done (Fr/2/21).

Prior to undertaking this placement Karl had thought that technology was using the ideas generated by science to make things people could use. His experience of working with science and technology appeared to have reinforced that view for him.

Karl thought that knowledge of the science of the melting of the metals had led to moves to use magnesium instead of aluminium and this led him to a conclusion

about the relationship between science and technology. He commented that "to probably improve technology in some cases, in some areas, you are going to need to know and understand the scientific background of what you are trying to do" (Fr/4/11). In this view Karl felt that science had to come before technology, but when he was asked if the technology could come first and the science be worked out later, he agreed that this could be possible.

Karl placed a lot of emphasis on the technology in the manufacturing plant, and saw it residing both in the artefact and the process, and contributing to improvement:

> Probably both in the equipment and the process. Like the casting equipment was probably, technology-wise, the most advanced in the world but then they have improved the entire process in that they have shortened the heat treatment time by six hours which in turn is all related to technology, which has cut down manufacturing time (Fr/4/11).

He described in some detail the 'technology' out in the manufacturing plant, being impressed with the robots used in the production line, which could machine the wheels without human intervention. For Karl these artefacts of technology were an important part of learning about working in an industrial environment.

Karl perceived that his work placement had shown him what it was like to work in a technology-based industry. He had learnt about the pressures of the industrial export marketplace, and how technology played a big part in creating better products. He perceived that he understood the problems a technologist might face in realizing a design. Karl had also come to some conclusions about the nature of the relationship between science and technology. He felt convinced after this experience that his career lay in a technology-based industrial company.

7.3.3.3 The Case of Vanessa

Vanessa was an Earth sciences major who completed two placements in the same research institute. Her interests were in soils and plants and at the start of the placement programme she hoped one day to work in a consultancy in these areas.

Prior to her first placement she felt that science was about understanding how things work and that doing science involved "pulling things apart to look at their basic structure" (Sto/1/9). She thought technology was the development of new ideas and concepts from science. She emphasised the need to understand the science before you could do the technology.

During her first placement Vanessa wrote of her learning about the process of science:

> I have found science to be a process. It involves trialling a thought, and analysing its outcome. Whether or not the outcome is the desired one, it still may have significance. Science is also much like a tree, branching off from one main idea into many smaller ones. It is also like a jigsaw puzzle, whereby minute ideas and concepts aid to make the bigger picture. However the bigger picture is never really finished, it is continually expanding (Sto/J1/4).

In her reflection in her journal Vanessa had come up with a number of concepts about the nature of science. The view of science as a process was one she held prior to the placement, but it is of interest to note her belief that the there exists 'desired' outcomes in science, as though science aims to show (prove) what is already known. She modifies this thought, however, with the rider that all outcomes may have significance, regardless of their 'desirability'. She noted that her work on placement threw up unpredictable results and this experience may have contributed to her thinking.

Vanessa's experience working alongside a scientist on a research project had led her to a conclusion that what she was doing was just a small part of a bigger picture. In particular she commented on how her research institute was involved in soil research from a number of angles and she was just contributing to one area. She had also tried to understand science in a metaphorical way by using the analogies of trees and jigsaw puzzles. Her use of these metaphors appears to extend her previous view of science as analysing a basic structure to include how that structure may be related to other entities.

Vanessa also held a view about the contribution of technology in her placement:

> It is technology which helps to continually expand the bigger scientific picture. Using science, we create technologies. Technology aids in speeding up the scientific process, as new technology is better than previous technology (Sto/J1/4).

This view echoed her pre-conception about technology being a development of science, which in turn was used in the scientific process. When describing what technology was, she felt that it resided within the equipment, particularly machines that scientists used.

In her second placement Vanessa contextualised these ideas about the nature of science and technology in her work:

> Science is in the thought processes behind what actually occurs within the soil and analysing the leachate and the effluent and things like that, especially the laboratory type work and just why the experiment is like it is, and what are we doing and what the purpose of it is? Technology out at the site it's, I think that's fairly basic technology like the lysimeters [instruments for measuring the soluble matter in soil] and how things are set up and how we collect the leachate, everything's fairly basic, it gets collected in buckets and the effluent is irrigated in buckets with little shower roses attached to the bottom so it's basic technology but used in a way that can be scientific and it works really effectively even though it is so simple (Sto/4.1/8).

This experience reiterated for Vanessa her views that science is the idea and the processes behind the work and technology is the equipment used to carry it out. She did not make any mention of technology being a process or originating with problems to solve. Her view of the relationship between science and technology was uni-directional:

> I think technology in some ways is your desired outcome in what you're trying to achieve, like you're trying to achieve new ways of doing things whereas I think science is getting to that, doing the basic research on all the readings and looking at journals and developing new methods and leading to new technology (Sto/4.3/19).

Vanessa saw science as leading to technology and not the other way around. When asked if technology could come first, she thought it unlikely. She commented at one point that first it was necessary to understand the science, before moving on to the technology, emphasizing that technology is the 'desired outcome'.

Vanessa recognized that her views of science and technology may have been different to other people's. She noted that "I think some of the ... maybe the technology people might see technology as being different to what I do, and science different. I just think it's your different background, where you come from as to what your views are" (Sto/4.3/19). Vanessa acknowledged that background or experience can influence learning about science and technology in the workplace and can be shaped by the context in which the student is placed. Her own experience of the operation of science and technology in the workplace had contributed to her views.

The opportunity to spend a year in total in a science research institute had led Vanessa to believe that she had learnt about the process of working in science and the use of technology. The experience had not substantially altered her ideas about what science and technology were but she had been able to reach some understanding of how they worked together in the workplace. She rated the experience very highly, enjoying both the work and the social interactions. However from the experience she realized that although she wanted to remain in the science field, she was not suited to the research workplace, feeling that she was "a people person" (Sto/4.2/8) and that being in a laboratory all day was not for her.

7.3.3.4 Summary of learning about the practice of science and technology

The three case studies of students in this study have illustrated that learning about science and technology can occur in the work placement. Being involved in scientific research or technological development led Vanessa and Karl to state that they had learnt about those processes in the context of their workplaces. Their learning was contextualised by the work in which they had been engaged. These

two students felt that they had had their prior views about science and technology confirmed and extended.

However, analysis of these three case studies has also shown that being placed in a scientific or technological workplace will not necessarily lead to learning about science and technology. Without participation in the scientific or the technological process, learning opportunities are restricted, regardless of the activities that may be operating elsewhere in the workplace. Participation appears to be important in helping students to understand the meaning of working in science and technology. This assertion was supported by the finding that in 10 out of 41 placements, students in this study felt they learnt nothing about science and technology because they were not directly involved in activities that they recognized as scientific or technological.

Students in this study also commented that there were other learning outcomes for them about science and technology in their workplaces. They learnt that science is methodical, that it takes time (see also section 7.2.2), that there are budget pressures and that scientists are normal people (that's a relief!). Two students also commented on the rapidly changing nature of technology. Rick noted from his electronics placement that the most important aspect of working in technology was "keeping up with the market"(Pa/2/17), and Martin found in his plastics industry placement that "new stuff" was coming out all the time and the industry was "forever changing" (Ri/2/19).

As well as learning about the practice of science and technology in the workplace, students in this study reported learning specific skills and knowledge through their work. The following section examines what the students felt they learnt in these areas on their placements.

7.3.4 Learning skills and knowledge in the placement

The students in this study were actively engaged in working in science and technology work placements. As such they were exposed to a range of tasks that might allow them to develop new science and technology skills and knowledge.

The next section investigates what the students reported in learning in these areas in their placements.

7.3.4.1 Learning technical skills

As noted above in the discussion of learning about science and technology, the learning about the practice of science and technology the students reported in their placements was contextualised by the activities they were engaged in. That is, what they learnt about science and technology was influenced by the nature of the company's business and the student's access to the different parts of that business. This contextualisation was also a key feature of the learning of technical skills by the students. The students reported learning skills according to what work the company was engaged in, and what tasks they were asked to do. These skills included learning how to operate machines and instruments, learning how to carry out particular techniques, how to use computer software packages and how to solve problems.

Working in science and technology often means using specialised scientific instruments and other machines. Many students in this study (14/22) specifically mentioned learning how to use particular instruments in their placements. Nigel stated that "I suppose the first thing is the machines that I learnt. There were some fairly expensive and user-specific processes going on" (Gr/4/6). This comment arose out of Nigel's placement in which he worked as analytical chemist, on analysis machines that he saw as specific to the industry he was working in. In all cases these students noted that they had not had access to those instruments in their university studies. It is likely that cost was a prohibiting factor in the availability of the instrumentation in the undergraduate classroom.

Science and technology is also underpinned by the use of specific techniques and methods. Mike noted that "I guess the different techniques have been a lot of the things that I've learnt, techniques for weighing, techniques for you know different analytical methods and things like that" (Mc/2/15). The learning of specific techniques was the most frequently reported skill in this study, with 16 out of 22 students acknowledging the new techniques that they had learnt in their

placements. Other examples included Grant learning laminating techniques (Be/4/3), Martin learning about plastic injection moulding (Ri/2/11), and Vanessa learning how to use lysimeters and carry out analytical chemistry methods (Sto/4.3/12). In one sense this high proportion of students could be viewed as an indication of the inadequacy of university education in teaching students techniques desired by the workplaces. However, it more likely can be viewed as a realisation that the university cannot teach the variety of technical skills required in the workplace. The exposure to these techniques in the work placement allows the students to augment their learning of technical skills in a direct and relevant manner.

Students commented on how their level of proficiency with particular techniques improved significantly with practice in the workplace. Previous exposure to techniques at university did not seem to affect this improvement, as Lucy commented in her second placement:

> Well, I'm quite an expert in whey ELISAs[2], little detail things like that, also the HPLC[3]. The only HPLC I've seen before working here was one I was shown at the university... that looks like it should be in a museum compared to the one we've got (Str/4/12).

Lucy perceived that her level of competence using these two techniques, ELISA and HPLC, had reached expert proportions during her placement. She noted that she was shown initially how to run the techniques, and then left to carry them out by herself. Prior to this placement, Lucy expressed concern about her ability to do the work, citing that she had completed only one ELISA test at university and that she "had stuffed that one completely" (Str/3/10). Yet at the end of her placement she had become the 'expert'. Additionally she had never used an HPLC before, although she had seen an old machine prior to her placement. Through using the HPLC instrument on a daily basis she felt that her confidence had increased, noting that "I think it's just coming to me now that I am quite capable of doing things" (Str/4/5). In fact she described how a new HPLC instrument had recently been installed at work and that she was the person who was teaching her

[2] Enzyme-linked immunosorbent assay
[3] High performance liquid chromatography

workmates how to use it. This transition from novice to expert had been facilitated by the opportunity to learn how to use the technique through practice.

Apart from technical skills directly related to their work, many students (10/22) commented that their computer skills improved significantly, particularly in using software packages that were specific to their workplace. In developing computer skills, and in many other areas of work, some students (13/22) also talked about learning how to solve problems through their work. This was often reported as involving collaboration, as noted by Hennessy and Murphy (1999), with workmates and by accessing knowledge distributed across the equipment within the workplace community. For some, like Jill, this was a major aspect of their placement (see Section 9.3).

In summary the students in this study reported that they learnt technical skills related to the work they were undertaking. These skills included learning how to operate machines and instruments, learning how to carry out particular techniques, how to use computer software packages and how to solve problems.

7.3.4.2 Learning knowledge in the workplace

As well as skills, the students in this study reported learning knowledge at work. This knowledge was, as with the technical skills, highly contextual, and concerned the work being carried out, and the nature of the placement organisation and its wider industry.

All the students in this study reported learning technical knowledge related to the work they were doing. In general those students working on a research project reported more learning of knowledge than those students who worked mainly as technicians carrying out routine tasks. This could be attributed to the small amount of information required to carry out routine tasks compared to that required to work on a research project.

For example, Kathy's first placement was in a local government organisation and, as noted earlier, these organisations are guided in their work by the New Zealand

Resource Management Act (1991). Kathy reported that "I've learnt an awful lot about the RMA [Resource Management Act], with the water work, and learnt a lot about GIS [Geographic Information Systems] and the consents database so, it's all things to do within the job I think" (Ba/2/13). She described how she learnt about the RMA through the course of work by asking questions of her supervisor and reading documents at work. She needed to apply this knowledge during her interactions with the public at work, and felt that she was learning as she went along. At that stage of her university studies, Kathy had learnt little about the RMA, and nothing about its applicability, in her course work.

In another example, Martin's second placement was working on a research project on ceramics. He described how although he had attended lectures in his courses at university on ceramics, he felt he had gained only a poor understanding and consequently little interest about the material. However his placement changed his view:

> I learnt a lot about ceramics and their uses, by talking to a lot of the other researchers there and finding out what areas they were researching, and the applications they used them for, and yeah it was really interesting to find out the wide range of products which can be made from ceramics (Ri/4/10).

Being situated alongside ceramics researchers in his placement had given Martin the opportunity to learn more about the knowledge and applications of ceramics. The experience had altered Martin's view through seeing and hearing about what could be done with the material. Participating in working with ceramics, talking to his workmates and learning about their work generated more interest for him and led him to believe that he was a lot more "comfortable" with ceramics after his placement.

The variety of placements that the students undertook led to a wide variety of knowledge gained by them, about the processes they worked with, the products they made and the way that science and technology industries operate. For example, Karl described that he'd "learnt a bit about the casting process, but I've probably learnt more about the general manufacture of an aluminium wheel"

(Fr/3/6). Jill worked in a cheese development team in one of her placements and she noted that before her placement that "I didn't know anything about which factories made cheese, and what kinds of cheese, and where they went. I've learnt about the different types of manufacturing" (Le/2/9). Jill's work involved trialling different sorts of cheese made at other factories, and a visit to another factory also helped her learn about cheese made there. By being involved in the company and the work it was doing, she gained knowledge about the technologies involved in cheese making.

Knowledge about how their company operates and what it does was reported as a learning outcome by 15 out of the 22 participants. For example Nigel reported learning in his first placement how the company rotated the laboratory staff around different jobs to provide variety (Gr/2/12), and Jill, who worked at three different dairy factory sites, noted how the security systems at each were completely different, despite being part of the same company (Le/2/8). A slightly smaller number of students (13/22) felt they had learnt more about the wider industry they were working in. For example, Karl noted that his placement company was almost "unique" in its industry in New Zealand (Fr/3/7), and Sally (Mo/2/7) and Jeff (Rh/4/15), who both worked in small forestry companies, concluded that the job opportunities were scarce and not that desirable in their industries. In some cases students who reported not learning about the wider industry felt that they had been confined to a small area of the company for the duration of their placement, and had not been able to experience how the company fitted into the wider industry.

In summary, the students in this study reported learning a wide range of technical knowledge related to their work during their work placements. Many also noted that they had learnt about how their placement company operated and the influence of the wider industry within which they were working.

7.3.5 Summary of learning about the practice of science and technology in the placement

As part of their BSc(Tech) degree, students normally undertake at least two work placements in workplaces in which science and technology is practised. This study has provided evidence that it is possible for a student to undertake significant learning about science and technology in their work placement. This learning is contextualised by the nature of the work being undertaken, and dependent on the student having a role that allows them access to the practices of scientists and technologists. Those students who worked directly alongside scientists and technologists tended to report a clearer picture of what it means to work in science and/or technology. For those students who reported working as routine technicians and labour hands, there was minimal learning about the practice of science and technology.

The learning that students achieved in the workplace tended to reinforce and extend their ideas that science is about understanding how things work and why they happen, and that technology is the application of that knowledge in creating a better product or process. There was a strong commitment to the notion that technology was the end result of science. This very pragmatic focus on the relationship between science and technology may be a reflection of the type of student who undertakes the work experience programme of the BSc(Tech) degree, as many students in this study spoke at the outset of the study of their desire to see their science and technology put to some practical use.

The work that the students were asked to do on placement had a direct bearing on the technical skills they learnt. These skills included learning how to operate machines and instruments, learning how to carry out particular techniques, how to use computer software packages and how to solve problems that were bounded by the context of their work. In some cases these skills would only apply to that work on placement, but in other cases the skills could be applied to other similar work.

Finally students in this study reported learning a wide range of knowledge through their work. This included scientific and technical information about the work

itself, an understanding of how their placement company operates and of the nature and opportunities afforded by the industry within which their company is based.

The students emphasised how the placements had complemented their learning at university. They described how they were able to experience the process of science and technology in an authentic community of practice, where the matter for practice *is* science and technology, and how they experienced the problems that were part of those processes. They discussed how they developed their skills and extended their knowledge in science and technology in a contextual manner by an immersion into a specialised field and how, in some cases, they changed their views about working in science and technology.

The opportunity to carry out a work placement in a science and technology workplace has been shown to contribute to a co-op student's understanding of what it means to work in science and technology. This had potential to influence the students' career decisions, and this is discussed in the next section.

7.4 Learning about a career in science and technology in the placements

To complete this chapter on the significance of the science and technology workplace context for student learning is an examination of what and how the students learnt about possible careers through the placement. Previous research has shown that a student undertaking a work placement in an area relevant to their study can gain information about a possible career (Dubick, McNerney, & Potts, 1996; Eames, Kumar, Rowe, & Hitchcock, 1996; Somers, 1995; Wessels & Pumphrey, 1995). Research has also shown that participation in co-op placements may have an impact on students' career identity (Weston, 1986). The placement experience provides the student with the chance to find out what it is like to work in a company or an industry of interest, to talk to practitioners within their career of interest, and to make contacts and build a work record, any of which may benefit them as they begin their career. An alternative view to the notion that co-op placement experience benefits career choice has been provided by Martello and Shelton (1981). Their study on career attitudinal and cognitive development of co-

op students showed their progress in development was not dissimilar to non–co-ops. They did find that co-ops had more career maturity (clearer idea of a career focus) and suggested that that may have caused them to select a co-op degree, thereby potentially skewing data that has shown co-op students having a clearer career focus *after* placements.

The concept of a career has been evolving in the latter part of the 20th and early part of the 21st centuries as workplaces undergo regular change, and expectations of employees' skills increase. In place of a job-for-life, and prescribed career paths, have come an average job lifetime of 3-5 years and the emergence of the need for lifelong learning (Greenhaus, Callanan, & Godshalk, 2000). The diversification of job roles has changed the onus of the career from being the property of the company to become the property of the individual. As Greenhaus et al. (2000) noted, a career is now defined as "the pattern of work-related experiences that span the course of a person's life" (p. 9). These work-related experiences encompass both the work itself and the person's perceptions and learning about the work. Co-op placements provide an opportunity to gain work-related experiences and to learn about work.

This section examines students' perceptions and learning about a career in science and technology through their work placements. It begins with the influence of the placement on occupational choice and job roles, and briefly describes the role that pay might play in students' perceptions of career. This is followed by a discussion on how students may be encouraged into further study by their placement experiences, and the final section reports on the transition of some students into a career position through their placements.

7.4.1 The influence of the placement on career decisions

Many factors can combine to influence how a student may make decisions about their career. These may include personality factors, financial factors, social and cultural factors. Occupational choice has been described as a process of matching occupations and personality (Holland, 1973). It is also a developmental process

that evolves over time and with exposure to different experiences (Greenhaus et al., 2000).

The BSc(Tech) placement programme gives students the opportunity to express an interest in a particular occupation and to try it out. They have the chance to reflect upon their experiences and develop their ideas of which career might suit them. In many cases students spend time in two, and sometimes three, different workplaces during their placements and can gain knowledge and experiences of what it is like to work in those companies and their industries.

Prior to undertaking their first placement, the students in this study were asked about their career ideas. Some students (6/22) had a reasonably clear idea of what type of career they were interested in. These students expressed conviction that they were heading for particular situations such as technology management or research in chemistry, but gave no further detail on a particular job role. The majority of students (16/22) however had only a vague notion of what they might do in their careers. As Nigel commented before his first placement "I haven't really got an idea of what's out there" (Gr/1/10). Most of the students (18/22) stated that the opportunity to find out what careers might be available was one reason for doing the BSc(Tech) degree rather than a non-co-op science and technology degree. Often they felt they enjoyed a particular subject area but didn't know what career they could pursue with their subject knowledge and skills. As Sally noted about her placement, "it's going to maybe point me in a direction of where I want to go in the forestry industry, because it's just so huge, you can be in the industry, or the support industry" (Mo/1/12). These findings do not bear out Martello and Shelton's (1981) notion that co-op students have a clear idea of career focus, but it remains a possibility that co-op degrees do attract students who are more concerned about investigating potential careers.

All the students in this study reported learning about possible careers through their work placements. They saw this learning as very valuable, and as providing a good indication of the type of career roles that might suit them. In some cases the placement experience confirmed the student's career interest, and in others it changed the student's career direction significantly.

Some of the students (5/22) found that their placement experiences confirmed their career direction. For example Victor had been programming computers since an early age but had somehow found himself studying electronics at university (even he confessed to being a little bemused by this). Prior to his placement he felt a position combining programming and electronics might suit him. His first placement allowed him to work in such a position and he enjoyed it very much (Ro/2/6). He returned to the same company for his second placement and towards the end of that placement he was offered an extended contract. He was positive about the value of his work placements:

> I would have to say 100% because I never really knew if I wanted to go into the programming side of things or the electronics side of things and here [at work] it's sort of a mixture between the two, so I'm programming and electronics and I'm pretty happy that I want to go in the direction of both, so that sort of answers the question for me (Ro/4/16).

Victor felt that his placements had suited his interests and had given him an indication of the type of occupation that could combine those interests. In his first placement he began by doing simple electronics tasks, before being engaged on a programming project. He did so well on the project that his second placement was entirely focused on programming work and he graduated to a position of teaching his workmates how his programme worked. The placements had given him entry into his desired career niche. In discussion he also noted that the work environment suited his personality, and that he felt able to get along easily with his workmates. He had wondered prior to his first placement what sort of people he would encounter in the workplace, as he had never worked in such an environment before. He appeared relieved to find that the people were like him, and he felt that he had fitted into that community of practice.

Other students (17/22) found their career ideas changing as a result of their placements. Nigel, who had never worked in industry before, found that his placement in a chemistry laboratory in a large manufacturing company was a revelation. He said "it's changed my whole perspective of industry and working in there. I think it has also changed my career direction slightly, because I've seen

working in industry, it is just totally different. It's given me some light on what options there are out there" (Gr/3/2). Prior to this placement Nigel had wanted to find out about career options, and he felt the placement had provided that opportunity. Nigel enjoyed the work and the social interactions in his workplace, but also became aware of other options that might be available to him through observation of the other job roles of people in his workplace. He felt that his placement had provided him with good career information.

Some students described how their career ideas changed as a result of their learning about particular job roles. Martin was interested in a practical job where he could use his hands, but his first placement turned out to be based mostly in the office. He commented that the placement had given him "an idea of what office work is like for a start. I wasn't too keen on it really. So it's changed my mind about that. I would still prefer more labour but I'm not afraid of this office work" (Ri/2/20). Through his placement Martin had learnt that his personality fit to office work was not as awry as he thought it might have been. He also described how he had talked with his supervisors about how their careers had developed, and learned that many had begun their employment on the factory floor and had progressed to office and managerial work as their responsibilities increased and they searched for new challenges. These discussions created a new awareness for Martin of possible career roles.

In contrast, Nancy was turned off the job role of a research technician through her experience on her first placement. She wrote in her journal that she had "learnt that being a technician is tough and people tend to take advantage of them. (Not really wanting to be one)" (Wo/J2/6). Interestingly it was not so much the nature of the work that Nancy disliked, but the regard in which she found herself in the science research environment. She felt that this regard of 'being taken advantage of' was not related to her being a student, but was a function of that job role. This insight into what it was like to work in the socioculturally-determined role of a technician confirmed for Nancy that she should undertake a Masters degree so that she could secure a career position in science in which she felt she could rise above that role and would not be taken advantage of. At the completion of her Bachelors degree, Nancy began a Masters degree.

In some cases students in this study altered their career ideas as a result of an unsatisfactory placement experience, and in others it was information they gleaned about the industry they were considering for a career. Jeff was typical of the latter group in learning about working in forestry. He found:

> Just that it's real competitive, stories I have heard, like not so much with the people I was working with but just in [a big forestry company] and that, it's real competitive and people back slaying each other and I couldn't be bothered with that sort of stuff, unless I got a job off the side sort of forestry, not directly with [the big forestry companies], everyone wants to get a job with them, it's good pay and that but I couldn't put up with all that (Rh/3/2).

Even though Jeff had not worked with the big forestry companies, it was the 'stories' that he had heard that were influencing his career decisions. As an insider in the industry while on placement, Jeff had access to these 'stories', which provided him with a view that he may not otherwise have gained. Jeff's learning through the social network had had a significant impact on him. Mike had a similar experience of learning from stories while on placement. He came into contact with graduates in his area of science who were struggling to find work, which led him to believe that he might have to go overseas to get a job after graduating (Mc/3/6).

One student in this study, Kathy, provided an interesting example of the career developmental process, leading to an unexpected outcome. Prior to her placements she expressed an interest in council work, and was particularly keen to work with water management. She completed two placements in regional councils in which she worked with two aspects of water management. From a matching point of view these placements appeared to suit Kathy perfectly and would give her an excellent view of her potential career. She enjoyed the experiences and could see that it would be possible for her to continue in the field, but towards the end of the second and final placement she made a decision to go teaching. She commented:

> I could very easily stay in this sort of arena in the council and be happy but I don't think I would be happy long enough to warrant going straight into it. I think I should try teaching and see what I think about it (Ba/4.4/16).

Kathy explained that she had been talking with a friend of hers about teaching and that it had suddenly dawned on her that that was what she would like to do. She had experienced what a science occupation would be like in her area of interest and found that, although she could do the work, it wasn't going to fulfil her as a career. She felt grateful that she had had the opportunity to find that out before she committed herself to that career. (Teaching degree programmes also contain an experiential component called a practicum in New Zealand. It would be of interest to examine Kathy's perceptions of her potential teaching career that she may gain from this experience).

A final influence on career choice that students reported learning about on placement was pay rates. For many of the students in this study, pay was not a huge factor whilst on placement and they accepted that they would not be paid well as a trade off for the experience they were getting. However, some students cited their learning about what they might get paid if they were to get a permanent position in their placement organisations, and that this had certainly influenced their career thinking. This was particularly the case in the public research sector of the Crown Research Institutes (CRIs). Vanessa commented:

> Well I know that science, talking to the other technicians, they don't get paid a lot more than I do. There's a big difference between what a scientist gets paid and what a technician gets paid as well. So working in an organisation like this, it is a bit of a worry about how little pay you do get. But it definitely has reinforced the idea of getting further qualifications after my Bachelors (Sto/2/6).

Through her participation in a CRI, Vanessa was able to gain access to knowledge about the community of practice that affected her career thinking. She was able to find out how much science workers get paid, and the knowledge had spurred her on towards getting higher qualifications. (In fact, Vanessa did not continue on to further study as she secured a job in another science sector organisation in which

the pay rate was much higher). Similarly, in Lucy's first placement in a CRI she noted that her friends were earning more than she was even though they had no university education, which she felt was unfair (Str/2/4). She completed a second placement in a commercial company where she was paid more and saw that she could make more money within the private sector. This experience convinced her that her future lay in the private commercial world of science and technology and at the time of writing that was where she was employed.

In general terms those students who felt comfortable with their pay rates were employed in the private sector. For those employed in the publicly-funded research organisations, there was a reluctant acceptance of the low pay rates. However, most felt the low pay could be offset by the challenge and interest of the work. In contrast the work in private commercial/manufacturing companies is often higher to compensate for the routine nature and long hours of work.

In summary most of the students in this study reported entering the BSc(Tech) degree programme to find out more about career options. They reported learning about potential career options through their work placements. Their placement experiences had helped them to make career decisions, learn what job roles might be available, learn about the industry they were interested in and what pay rates might be like. The majority of the students felt their placements had altered their career views in some way. Much of the learning about careers was achieved through social interactions in the workplace and the opportunity to experience what it means to practice in their area of science and technology.

7.4.2 Encouragement for further study

For some students in this study their placement experiences influenced their thinking about enrolling for further qualifications in science and technology. Of those students (12/22) who indicated an interest in further study in science and technology prior to undertaking their first placement, seven (58%) had their plans reinforced by their placements. Of the five who didn't carry on to further study, four got jobs with their placement organisations, perhaps negating in their eyes the immediate need for further study.

Of those students who did not plan to do further study before their first placement, only one, Duncan, changed his mind after his second placement. His decision to enter into a Masters degree programme was influenced by his experience in both of his placements. Duncan's first placement led him to discover that he enjoyed research and his second placement involved learning about organic farming, which he found extremely interesting. The combination of these experiences convinced him to undertake research study in the area (Ho/4/17).

For those students who found that their placement experiences reinforced their interest to do further study, two factors were prominent. Reinforcement occurred either as a result of conversations in the workplace about career options and the qualifications required for those options, or as a result of experiencing the type of work that they might be able to secure as a graduate with a Bachelors degree.

Donna had come into contact with a number of new graduates in her first placement, and their experiences in gaining employment had shown her the need for getting a Masters degree in order to get a job. She commented:

> There are a couple of people down here [at work] with Bachelors degrees that are just on contract, three month contract, and I mean they tell me how hard it has been for them to even find that three month contract, and so it's made me really aware that to find a job you need a Masters (Ni/3/1).

Interestingly Donna was able to return to the same workplace for her second placement and towards the end of that placement applied for and secured a permanent position with her nearly-completed Bachelors degree. So for Donna at least, by virtue of having established a work record and making contacts in the company, her anecdotal evidence of the requirement for a Masters degree to get a job in her field was negated. At the time of writing she is still in her job, and although her duties have changed, she is enjoying her work.

Gaining knowledge of what it was like to work in science research gave Nancy a pointer to how she needed to progress her career to get what she wanted. Her first

placement experience showed her that she needed more qualifications to reach the level of work she aspired to. She noted:

> I'm going to do postgraduate study. So I can get to the stage that I can do the things that I would like to research. Rather than be a technician doing the same thing, like a person that runs one of the instruments. I wouldn't want to be stuck at that all the time (Wo/2/22).

Having worked as a technician in her first research placement, Nancy had experienced what that was like. As noted above in Section 7.4.1, she felt that technicians were taken advantage of, and elsewhere commented that they "did everyone else's work"(Wo/J1/6). Only by being put in that situation and experiencing how it felt had she been able to come that conclusion. Prior to her first placement she had indicated an interest in doing postgraduate study and this experience really confirmed to her the need to do so in order to reach beyond the career role that she had so far experienced. As noted earlier, she undertook her Masters degree, and at the time of writing has just begun a doctoral research degree.

In summary, some of the students in this study were encouraged to undertake further study by their experiences in their placements. This influence came by way of learning about new study areas, learning from workmates about career options, and by learning from direct experience what particular career roles were like. These opportunities to learn about careers during their study gave a clearer career direction to the students. Some students did not carry through their prior plans for further study as they secured a permanent position directly as a result of their placements. These students experienced an easy transition from student employee to permanent employee and this transition is examined in the next section.

7.4.3 Making the transition from student to employee

One of the outcomes of tertiary study for a student is to find meaningful employment using their tertiary learning at the end of the study period. This outcome has often been upheld as a key benefit of a co-op programme, in that the

combination of classroom learning and workplace practice makes the student more employable. It is presumed, and has been suggested (Somers, 1995), that students who undertake placements as part of a co-op programme, gain employment skills and make contacts that lead to employment. In 2001 of all graduates of the BSc(Tech) programme who were not engaged in further study and who had been looking for work, 60% were employed by their placement organization (Cooperative Education Unit, 2001).

In this study 13/22 students did not continue with further study. Of these, six students (46% of employment-seekers) were initially employed by their placement organisations, three were employed elsewhere (23%) and the destination of the remaining four (31%) is unknown.

The six students who gained employment in their placement organisation experienced the transition between student employee and permanent employee in the same organisation. For all these students the transition was smooth and largely untroubled, and none of the students expressed any concerns about taking on the role of a permanent employee. Their placement experience may have enculturated them into the community of practice, and some noted that as they moved from student employee to permanent employee, they appeared to move away from the periphery of the community towards a more legitimate position. This change of status was welcome, even if the change took a while to sink in for some of their work colleagues. Donna commented "I guess one problem I found was that people still were of the mind that I was a student so quite often they would get me to do jobs for them and it was up to me to say 'well no that is not in my job description', so I couldn't do it" (Ni/4/2). For Donna, and for Victor who experienced the same transition (Ro/4/3), there was relief that they would no longer have to do some of the menial tasks that used to be their lot as students. They felt that they had served their time as students and now had responsibility beyond their perceived student role.

The major change that students who made this transition commented on was the extra privileges that they had access to as permanent employees. This mostly involved access to training and better pay rates. Jill said "I'm allowed to get

training, like actual forklift training or work permit training or you know, all the stuff I needed before but I just wasn't allowed" (Le/4.5/2). As a student it had frustrated Jill that she was doing the same job as the permanent employees, yet she was not getting the opportunities to develop her abilities that her colleagues were getting. These differences extended to pay structures as well for most students including Jill. In Donna's transition, her move to permanent employment status meant a 66% pay rise. While she was, not surprisingly, delighted with the change in pay for doing basically the same job, it led her to conclude that organisations were "able to get away" (Ni/4/3) with paying students less.

Apart from these changes to training opportunities and pay rates, the students who made the transition from student employee to permanent employee in their placement organisation experienced few changes and found themselves well equipped to assume the status of practitioner. They perceived that the learning that they had achieved through their degrees and their placements had contributed significantly to the ease of that transition. This transition is discussed in more detail in the Chapter 9, which presents case studies of two students and their experiences of their co-op degrees, and how they learnt about what it meant to be a science and technology practitioner.

7.4.4 Summary of learning about a career in science and technology in the placements

Co-op programmes promote the work placement as a means for students to learn about career opportunities and to develop their own career identity. Most of the students in this study reported that they entered the placement programme to learn more about possible career options. All of the students reported learning that contributed to their career decisions. This learning was achieved through social interactions in the workplace, through observation of job roles and direct immersion into work that created meaning for the students of what it was like to practice in their area of science and technology.

These placement experiences influenced the students' career thinking, either reinforcing ideas or changing them and allowing them to experience and observe

roles in particular communities of practice that they could evaluate. Students gained knowledge of the level of qualification that they would need in order to reach their career goals, and about what sort of pay rates they could expect. Students incorporated this placement-derived knowledge into their career development (Greenhaus et al., 2000). For some students, their placement experiences confirmed or altered their thinking about continuing on to further study in science and technology.

One of the opportunities that exists for co-op students is to secure a permanent position with their placement organisation, through being able to show what they can do on placement. Employers have often used this 'try before you buy' approach to recruit staff from co-op programmes. In this study almost half of the students looking for permanent employment were taken on by their placement organisations. These students found the transition to permanent employee straightforward. They found they gained a more legitimate position in the community with increased responsibility, better access to training and improved pay rates after the transition. In becoming permanent staff they experienced no difficulty adjusting from being a student, having already been enculturated into their workplace during the placement. They endorsed the proposition that their placement experiences had been important in allowing them to make the transition from student to practitioner in their science and technology workplaces.

7.5 Chapter summary

Analysis of data provided by students in this study has shown that the students have learnt about the contexts of the science and technology workplaces in New Zealand, the opportunities and constraints that exist within those contexts and the reality of what it can be like to work in those contexts. The placements have provided opportunities to learn about the true meaning of the commercial world, whether it be working in a commercial production environment with the pressures of the marketplace, or the funding requirements of science and technology research. Students felt they had gained a greater understanding of what these issues mean through their participation in the everyday activities of the placement companies, through their involvement in their company's enterprise and through

accessing the socially negotiated meaning inherent within the community in which they are beginning to practice.

Through placement into these contexts the students have come to share in the knowledge and skills distributed amongst the community of their workplace. They have experienced how their learning of science and technology in these workplaces is related to the tasks at hand and may be closely, slightly or not at all related to their learning at university. They found that the opportunity to practice skills in the workplace has developed their expertise and increased their sense of confidence and value.

Being situated in communities of science and technology practitioners has afforded students the chance to learn what it is like to practice as scientists and technologists. Greater learning was perceived to occur when students worked closely with scientists and technologists, and when they were able to access a range of experiences in their placements.

The students in this study reported learning about what career options were available through their placements in science and technology. This learning was achieved through participation in authentic activities and roles within communities of practice that created meaning for the students of what it was like to practice in their area of science and technology. The students were able to understand whether such practice was suited to them in a way that would be impossible to achieve in a university setting. It may only be achieved through being given legitimate participation (Lave & Wenger, 1991) in a community of practice, in a way that is offered by a co-op work placement.

The analysis of the findings presented in Chapters 6 and 7 has argued that students can learn about the practice of science and technology in the sociocultural setting of the workplace through co-op work placements. The next chapter investigates the complementarity of that learning with their learning at university, and any differences between learning in the two sociocultural settings that may be important to understand for curricular and pedagogical reasons.

Chapter 8 Results and Discussion

The complementarity of learning in two sociocultural settings

8.1 Chapter outline

It has been argued in Chapters 6 and 7 that students can learn through their participation in the sociocultural setting of the placement. It is also accepted in this thesis that students can learn through completing courses in the university setting. But how does the learning in these two different settings complement each other? One of the main arguments for justification of co-op programmes has been that placements provide students with the opportunity to apply some of their coursework learning to the workplace, and a corollary to that is the opportunity for learning in the workplace to feed back into coursework at the educational institution, processes known as integration in the co-op community.

The students in this study were provided opportunities, by virtue of the BSc(Tech) programme structure, to apply their university learning to the workplace in their two placements, and for learning in the workplace to be applied at least in their third year of courses, and in some cases in their fourth year of courses. This chapter explores how students made links between learning and its assessment at university and in the placement, and investigates the complementarity of the two sociocultural settings for learning.

8.2 Integrating learning between university and the work placements

This section examines the students' self-report data about the integration of their learning at university and in the work placements. It begins with an analysis of the students' perceptions prior to their first placement of how they might be able to apply their studies in the future. This is followed by a discussion of how students felt they were able to apply their university learning in their placements, and then how the students' felt learning in the placement integrated back into their university study. To complete the section is a discussion of how the students felt their university learning complemented their workplace learning.

8.2.1 Students' perceptions of their university studies prior to their work placements

Students in this study were asked about their perceptions of the relevance and applicability of their university courses prior to undertaking their first work placement. At this point no students in the study had had the opportunity to apply the knowledge and skills learnt over their two years of coursework in a science and technology workplace.

Two main perceptions were reported by the students as to how they saw the relevance and applicability of their university courses to the workplace prior to undertaking their first work placement. Firstly, almost half of the students (10 out of 22 participants) felt unsure as to the relevance of their coursework to the workplace because they had not experienced a workplace where their university-learnt knowledge and skills could be applied. For example Vanessa commented:

> Sometimes it's like, I don't know if that is really going to apply, but on the whole I think it does because I'll find that out when I get to my workplace, because I haven't had a job really before where I have been able to go in and apply my knowledge (Sto/1/5).

For Vanessa, her lack of knowledge of what was required in a science and technology workplace left her wondering how useful her studies might be. It was interesting that no students expressed an implicit faith that the knowledge and skills the university was teaching them must be useful for the workplace. An additional factor in this uncertainty about the relevance of their university learning for some students (6/22) was their own uncertainty of where their career may take them, and hence what parts of their coursework might be of use to them. For example, Kathy noted that although she was not sure what job she was going to do after her degree, she felt that her courses would not have "a direct relevance to what I'm going to do when I get into the real world" (Ba/1/3).

The other main student perception (12/22 students) that arose from this investigation about relevance of university study to the workplace was that they

would be able to use their university-learnt knowledge and skills as a base to build on. Martin noted:

> The knowledge we learn here is basically the basis of what is happening in the world at the moment. I mean they can't teach you everything that is happening right now, in university. You can't fit it all in, so this is giving you the base of what people know, the foundation and then with these work placements you can add on. That's the whole idea of them. Once you get out you can add on to what you know from university and you can soon catch up to what's happening (Ri/1/3).

Martin saw his placements at that stage of his degree as adding on to his university-based learning. He implied that he would need to catch up to what is happening in the workplace, as his studies could only give him a base knowledge. His implication did not seem to be that what he was learning at university was out of date, rather it was just a sample of the knowledge he would require. He found that these preconceptions were borne out in both his placements. In his first he found himself learning more deeply about plastics injection-molding, that he had learnt a small amount about at university (Ri/2/11), and he reported the same in learning about ceramics in his second placement (Ri/4/10).

The notion that the university could not possibly teach a student everything was also expressed in Karl's view of the relevance of his studies:

> When it comes down to it, some of it you will use, and some of it you won't. Depending on your occupation obviously. And I mean the difference between me and someone else, we could do the exact same papers and everything, but we could use totally different parts of what we have learnt. But the key thing there is that the university teaches you to learn, which is what you are going to do for the rest of your life out in employment (Fr/1/4).

In this view co-op qualifications provide students with a breadth of knowledge and skills, and work placements hold potential to allow more specialized exploration and development of that knowledge and skills. Karl also noted the importance of learning how to learn at university. He was the only student in this study who mentioned this aspect of learning prior to the first placement. This may

have been a reflection of his relative maturity in age (24 years) and experience in the workforce (four years).

The students in this study also discussed prior to their first placement how they felt about the usefulness of knowledge compared to practical skills learnt at university. The students felt that their learning in their university laboratory classes would be either more useful to them in the workplace than the theory they learnt, or that theory and practical would be equally useful. For example, in Mike's view, learning practical skills was most valuable:

> I guess the techniques, especially in things like soils, the techniques that you use in the workplace probably and it's like the practical application of what you are learning in lectures, it makes it a bit more real (Mc/1/3).

Mike did admit to being more interested in practical applications of theory, and he felt that the skills he was learning at university would be most useful in the types of workplace that he was interested in, in which he hoped to work in a hands-on way (Mc/1/9). Others supported the notion that what they had learnt in laboratory classes would be important, because they would have already tried out some of the techniques before. For example, James noted:

> By doing it yourself, you actually know what you have done to get it working. You don't watch someone do it and think 'I know how to do that'. Next time you come to do it you find that you can't. It comes back to a confidence thing, you know that you have done it yourself (Sk/1/3).

James perceived that having done tasks himself before would help his confidence for being able to do the same or even different tasks in the workplace. This issue was also raised by Lucy in Section 7.3.4.1, but in her case she was worried about having to use a particular technique in the workplace because she felt she had lost confidence in using it after a bad experience in her university laboratory classes. These comments suggest that confidence gained through doing practical work at the university before entering the workplace was an important issue for these students. Critically though, this evidence indicates that it is not sufficient to merely do some practical work at university to gain that confidence, and as Lucy's

experience showed, confidence could actually be adversely affected through perceived failures in practical classes.

Students in this study also noted how practical work helped their understanding of theory at university. Nancy emphasised how her university laboratory classes helped her to see the application of the theory from the lectures:

> It applies the theory to a real situation, so it's been really good, because what we learn in the lectures just sort of goes over the top of your head. And then to actually see it happen makes so much more sense (Wo/1/3).

This opportunity to see theory-in-action in the university laboratory was important to Nancy. This view was echoed by most of the students (19/22) in regard to their university studies. It may have contributed to the perception of the students that skills rather than knowledge gained at university may be more useful in the placement, as they knew they would be engaged practically in doing tasks in the workplace. Another factor to be considered is the possibility that co-op degrees such as the BSc(Tech) may naturally attract students who are more practically-oriented due to the placement component.

In summary students in this study perceived, prior to their first placement, that they were either unsure of the applicability of their university studies to the workplace, or felt that they were gaining base knowledge and skills which would be built on in the workplace. They also felt that if they were able to use their university learning, their skills rather than their knowledge may be most useful. The following section analyses what they felt actually happened in their placements.

8.2.2 Students' perceptions of their application of university learning in placements

Most of the students (20/22) in this study reported that they were able to apply some of their university-learnt knowledge and/or skills in their work placements. The reported amount of applicability was highly variable between students, and

even between placements for the same student. The students were more certain that they were able to apply their university learning when they were able to identify discrete skills or knowledge from their university classes that they had used in the workplace.

For example, Donna was one of the students who felt that she was able to apply both her university knowledge and skills. She had expressed an interest in water science prior to undertaking her placements, and was subsequently placed in a local council monitoring groundwater. This allowed her to see that her university course on water science (hydrology) had been very useful to her in the workplace. At the end of her second placement she commented that "what I learnt at university has been very helpful with what's needed with ground water. If I hadn't had it, I think I would have found it very difficult working here" (Ni/4/15). Donna found that her university knowledge helped her to understand the work she was doing, and the integration of her interest in her studies and the chance to experience working in a career position related to that interest was valuable for her. At the end of her degree she reported great satisfaction with her qualification and the education she received and placed high value on the opportunities that she had been given. Whilst in her second placement she applied for and won a permanent position as a water scientist in the council, and was thrilled to have her new job.

In another example, Lucy found herself using some university knowledge in her second placement about how some of the methods she was using worked:

> Just principles of chromatography, things like how does reverse phase work, how does gel filtration work, how do you make a calibration curve, things like that, and ELISAs[4], I was familiar with that, before I worked here. And now that I've just been assigned to set up SDS PAGE[4]. If I didn't go to university I wouldn't know what that meant, so I guess that's helpful too (Str/4/16).

[4] ELISA – Enzyme Linked Immunosorbent Assay, SDS PAGE – Sodium Dodecyl Polyacrylamide Gel Electrophoresis

Lucy was adamant that it was the theory behind the method rather than the practical skill that she applied, as she didn't believe that she had 'learnt' the practical skill through having one go at it at university. She commented:

> I think [I used] more of the theoretical knowledge because my practical, like you do a technique once kind of thing [at university] and then you'd move on to another technique, so it wasn't really long enough for you to get a good grip on practical skills needed, so I'd say more the theory (Str/4/16).

In Lucy's view, one practice of a technique at university gave her an understanding of the background to the technique but did not give her sufficient confidence to feel that she had 'learnt the technique'. She noted that the chance to carry out the technique many times was important in the workplace for her to learn the technique well, and even to become expert. Learning of practical skills through practice was a common theme for students in this study and is discussed elsewhere (see Sections 7.3.4.1 and 9.2). The learning of techniques in university classrooms can be viewed as having a different focus to the workplace. In the classroom the learning of techniques is constrained by a focus on demonstrating application of theory, and providing a suitable breadth of exposure to a variety of techniques. In the workplace, techniques are learnt on a need to know basis for immediate use, and are often practiced several times, leading to better skill development.

Applying their university learning as a background for their work, but not being able to identify anything specific that they were applying, led students in this study to express less certainty of their applicability of university learning to their placement. As Victor commented:

> I'm learning different things. What I learned at uni. is more of a base for my knowledge. What I'm learning here is off that. I guess if I didn't have that knowledge at the University I might be getting a little overwhelmed here, and I might not even maybe keep up (Ro/2/16).

Victor credited his university learning with allowing him to understand the new knowledge and skills he was gaining at work, and that without it he may not have

coped. His emphasis on learning different things points to the individuality of his workplace in extending his knowledge and skill base beyond the 'background' that he had learnt at university.

For a few students in this study (2/22) there was no apparent link between what they had learnt so far at university and what they were doing at work in their first placement. For example, Sally had a salutary tale to tell of a situation in which she and a fellow student attempted to apply a theoretical concept out in the forest and it didn't work:

> We had all this theory but it just didn't work when we tried to use it, so that was a bit dodgy. Like when we were trying to work out angles to get heights of trees, we had a calculator and we thought we had the formula. But you think in the forest, guys don't have calculators there to work out tree heights. We had to use a height thing to measure each tree, whereas someone could just stand there and look. The supervisor was saying that generally people could stand in the middle of a plot and estimate how many trees are going to be in there, but [my fellow student] and I were walking to each tree. So it's obviously just tricks of the trade and doing it for so long. It was good to have the theory but it was frustrating that we couldn't apply it, but that could be because we did learn it and then we didn't use it so we had shoved it to the back of our minds (Mo/2/6).

Sally was surprised to find that the theory learnt at university wasn't used in the same way out in the field. From this experience she perceived that there must be 'tricks of the trade' that can only be learnt by doing the task over a long period. Her mention of her supervisor's comment about how experienced workers could estimate tree numbers seemed to confirm for her the view that there were practical elements about the job which could only be learnt in the workplace, and over time, and that application of ideas and theories direct from university was not always possible. She felt that her university knowledge had given her a background knowledge, but was frustrated that she couldn't apply her learning directly, leading Sally to think that because she had not used it when she learnt it at university, the knowledge had been partially forgotten.

Finally an issue commented on by students (5/22) was the lack of technical equipment available at the undergraduate level in the university compared to the workplace. They saw this as an impediment to the integration of their learning between university and work as they had never had the chance to gain any experience on the equipment before entering the workplace. For example, in Craig's case this meant not being prepared for working on the internet "because at university you don't have dial-up connection to the internet" (Su/2/7). As his work was heavily based on the internet, he felt that he was not able to use any of his university learning at work.

In summary, the students in this study reported good application of their university learning to the workplace when they could identify discrete knowledge or skill areas of their university learning that they were using at work. These students noted that they extended their practical skills through practice beyond the opportunities they had had at university. Some students reported that they felt they were only using their university learning as a background or base upon which they built new learning at work. A few students felt they could apply little or nothing of their university learning to their placement. This was attributed to either not having the practical experience that is learnt 'on the job' that would allow them to adapt their knowledge to a particular situation, or not having been exposed at university to specific technical equipment used at work.

Hence, the students in this study did report that integration could occur between learning knowledge and skills at university and its use in the placement. The next section looks at what the students reported about using their placement learning back at university.

8.2.3 Students' perceptions of the application of workplace learning to university study

The notion of integration between university and the workplace through co-op programmes implies a two-way process. The previous section examined the university to work direction. This section focuses on the students' perceptions of how they were able to apply what they learnt in the workplace back into their

university courses. These self-report data were obtained from the students when they had completed their first placement at the end of their second year of study, and were in their third and final year of university study.

Most of the students in this study (17 out of 21) felt that their learning at work had influenced their learning at university in some way. For some students, like Nancy, that influence didn't become apparent until she was back at university doing her coursework, as she noted:

> When I was working there at first, I didn't actually think I was learning all that much but the input to some of the courses is pretty phenomenal. I think I've seen all sorts of connections ... and actually had enough practical experience I think from the work placement to make sense of the theory that we have done now. It was quite neat (Wo/3/1).

Nancy provided an example of how she had used a particular technique (gas chromatography) during her placement and had become very proficient in the technical aspects, but had never really understood the theory behind what she was doing. Her third year course at university provided that theory and her work subsequently made much more sense to her. Her emphasis in using the word 'enough' to describe her practical experience points to her perceived need to gain sufficient practice using a technique (which she gained through work) for her to be able to understand the use of that technique.

The students in this study reported a broad range of applications of their workplace learning. For example, Donna felt she had gained an advantage in her courses due to the experience she had had doing fieldwork on her placement (Ni/3/1). Mike, Jeff and Lucy found learning some concepts in their third year courses easier due to having seen them in action in the workplace (Mc/3/7, Rh/3/7, Str/3/9). Nigel felt his university laboratory work had improved due to habits he had learned in the laboratory at work:

> I've learnt that labelling is so important, time management, keeping the desks and what have you clean for proper use. Keeping the equipment clean so that I understand why that gives

> better results, that sort of thing. So the laboratory side, I felt the [placement] experience gave that quite a boost (Gr/3/9).

Vanessa attributed her improved report writing in her coursework to her experience in writing reports on placement. She noted that "the report writing has made my reports, my lab reports a lot better. I sort of understand the structure and things like that a lot better now. Just how to set things out and using the right language and things like that" (Sto/3/10). This outcome for Vanessa may equally be a function of the placement experience as the work itself, in that the report writing she refers to is part of the assessment of the placement. The report writing process involved having her report edited and commented on by her supervisor and other colleagues at work, thereby learning from their experience in writing.

Two students, Kara and Grant, were able to directly attribute their good grades in specific third year courses to the learning they had gained at work (De/3/8, Be/3/7). In these courses they felt the practical experience and knowledge they had gained about the work contributed directly to them gaining an advantage over their classmates. Kara commented:

> Doing Resources and Environmental Planning in the first semester, the RMA [Resource Management Act], I mean basically one whole section was all on resource consents and things like that, so I mean that was just a breeze really so it was quite good from working somewhere where I hadn't seen the Resource Management Act [in use] and then going to do it at uni, I could apply it because I knew how you actually used it in the work force, how important it is (De/3/8).

Kara had worked in her first placement with resource consents that resource users apply for under the RMA. Although she had no knowledge of the RMA prior to the placement, her subsequent learning about it in her third coursework year at university was given greater meaning through her previous experience of enacting it at work. Kara noted how her previous work with the RMA had helped her to improve her academic performance in one course at university (De/3/8).

Three students felt their workplace learning had affected their study practices at university. For example, Karl found he had become a more independent learner

and that since having been in the workplace, he would try to work questions out for himself instead of asking for help early on. Duncan found himself treating his university day like a workday, and would spend non-class-time studying at university instead of going home or to do other activities. Habits gained at work were also carried over into his university life by Rick, as he adopted a more self-motivated approach to his studies: "Before I used to be purely, 'well I'll just do this because this is required' but now I head on to the internet and I read, pretty much habits I picked up at [my placement company]" (Pa/3/11). Rick's new work-derived habits had shown him a way to understand the relevance of what he was studying, and provided him with his inspiration. Rick commented a number of times how he had adopted habits learnt in the workplace from his co-workers (see also Section 6.4.2), indicating that his participation in the community of practice at work had led to his enculturation into the ways of working of members of that community.

For four of the students the work placement led to a change in study direction, or, at the least, an alteration to their course choice in their third year of university study. This occurred in Donna's case due to her new interest in groundwater, gained through her work on placement; in Kara's case due to her improved understanding of what knowledge is required in the local government workplace; in Grant's case through having experienced what a potential career in wood processing has to offer; and in James' case through discussions with his work supervisor about what skills he would need in the telecommunications industry.

There were a few (4/21) students in this study who felt that they had been able to use only a little learning from their workplace back at university. In these cases, the students felt that the knowledge they had learnt at work was only a small part of their coursework and that the learning from the workplace had few links to their degree. This group included the same students who had reported that they had been able to apply little of their university learning to the placement, and for these students the placement was a completely separate part of their degrees, with no integration of the two learning contexts. For example, Grant commented about his placements, that "I haven't really worked with science and technology in either of them" (Be4/16). This is discussed further in the next section.

In summary most of the students (17/21) in this study reported that they were able to apply learning achieved in their work placements back at university in their subsequent coursework. This integration was represented by a better understanding of theory and improved skills through the practice of work, an improvement in grades due to knowledge gained in the workplace, a change in study habits, or a change in course choice.

8.2.4 The integration of the university and workplace learning environments

Having examined how learning at university and in the workplace was integrated for the students through work placements, the discussion now turns to consider how coursework and placements fit together in a co-op programme. This section focuses on the differences in learning processes that students perceived between the two sociocultural settings. The students in this study reported learning about how learning in the workplace and university settings differed in terms of its timeliness and how its outcomes were valued, and allowed them to draw conclusions about how they felt their placements complemented or integrated with their university study.

All 22 students in this study perceived that they learnt in a different way at work to the way they learnt at university. Many of the views focussed on the synchronicity of learning to its application, of the need-to-learn at work compared to their learning-for-the-future view of their coursework. Craig commented that "I'm learning as I go (at work), rather than learning for what I think is going to be happening later on. Just learning what I need to know" (Su/2/8). The learning on a need-to-know basis was a strong theme that came through the students' views of their learning at work. They saw it as relevant, hands-on learning, as Sally noted:

> You are actually learning real stuff, stuff that is used, and you are learning it because you can see how it is used, it's a live thing, whereas at university you sit down and you are told things. But when you are out there [at work] you are actually learning it and applying it straight away. Hands-on learning (Mo/2/6).

This view of learning that can be applied straight away was a dominant one in the study, and students saw this view as different from how they learnt at university. University learning tended to be seen as background learning that would be useful one day, for example in the placement. As Mike commented at the end of his degree, "I think university's good, like the academic courses are really great for providing that background information, but then it's got to be applied on the job" (Mc/4/15).

As discussed in Section 8.2.1, a number of students (10/22) expressed uncertainty over the applicability of their university learning throughout the study, and were concerned that they would finish their studies and never use that learning. For example, Kara reported that it was only in her final placement, when she was able to relate some of her university knowledge directly to her work, that she was convinced that her coursework had been worthwhile. She commented:

> I think by working there at [my last placement], specifically it's made me see that you do use your degree, I think, and that was one of my big fears that I would go to do this degree and go and work somewhere where I would never use it ever again, and it's in that context it's made me see that you do definitely utilise it (De/4.5/11).

Prior to this placement Kara had placed greater value on her placements than her university study, and had seen the two learning environments as quite separate, but this final work experience opportunity showed her that both parts of her degree were important. She explained that "I always thought the placements would be [more valuable] but now that I am at the end I would say that they both go hand in hand really" (De/4.5/11).

Students also commented on the different values placed on learning in the workplace and university settings. A major source of difference for the students was the practical learning environment. At university this is predominantly the laboratory or the field trip, and some students saw the value placed on learning in this setting as quite different to that which they experienced in their placements. For example Vanessa commented:

> Things aren't always going to go right the first time, and that's what I didn't realise about working in science. Unless you're working here or in a lab somewhere, you hear about the results but you don't hear about the problems that go along to get the results. And even at the university it's like you have got to do it right the first time, because you are going to have to write this up for next week, or you will get all your results from your team-mate. At [university] you can't go back and repeat it. It's now or never, with pressure to get it right the first time (Sto/2/14).

Vanessa had experienced a lot of problems with equipment failure and inconsistent results whilst conducting scientific experiments in her first placement. This led to a lot of work in fixing the equipment and repeating experiments. These experiences were entirely new for Vanessa, whose previous exposure to practical science in university and school laboratories had been carried out with equipment that was checked by someone else beforehand, and gave results that the teacher could predict. Where problems had occurred in the laboratories, there was no time for repetition and the teacher would explain what should have happened.

Donna made a similar observation about the difference in value placed upon her learning in university practicals and what was required in the workplace:

> I think the general feeling in my labs is that you do the work and if you don't get very good results, you know, it doesn't really matter. And a lot of my field trips have been like that too, but I guess when you're working and you're doing it for someone to write reports about, it is important to get good data (Ni/3/9).

Donna felt that the key difference between working science and university laboratory science was that, for the former, process and outcome were important, whereas for the latter only process was important. The view that the outcomes of practical work weren't really important in university was echoed by other students in the study. Their experiences in university practicals of the lack of importance placed on the outcomes obtained caused some students to express concern about their ability to deliver acceptable outcomes in their workplaces, as they felt they lacked confidence to do so, due to their previous experience in having this ability under-emphasised at university. They were concerned with their ability to produce

good outcomes when they felt they really mattered, in the workplace. This perceived difference in emphasis on the outcomes of practical science between university and the workplace is a cause for some concern, and has implications for the way students are taught at university.

A further difference in the value of learning between university and the workplace was commented on by Rick. He claimed that "universities love doing the approximations, and 'we will disregard this and assume this is perfect', and I mean it makes the maths very nice and all that, but it's totally different when you get out there in the real world" (Pa/3/2). In Rick's subject area of theoretical physics he could see that derived theorems used to explain behaviour in a model did not always work out when applied in his placement, and his experience had shown him that other factors needed to be taken into account and trials conducted to analyse the actual behaviour of the system. As noted earlier (Section 8.2.2), Sally had had a similar experience of the usefulness of theoretical models in the field.

Finally Karl's experience gave him a view on the different value that the university and workplace environments placed on outcomes of work. He made this point about assignments at university after he finished his placement:

> You know deadlines of assignments that are worth two percent were just, I felt, silly at the time. Got over that problem now but just little things like two percent assignments. You don't do two percent assignments when you are in the workplace. Not two percent assignments that take three days and things like that. Two percent assignments at [my placement company] will take you an hour (Fr/4/8).

Coming back to university after spending a year on placement, Karl had trouble adjusting to gaining so little perceived value, that is two percent, for spending so much time on a task. He saw a difference between the way the university and the work environments valued tasks and the reasons for doing them. At university tasks are often extrinsically motivating by their assessment value, whereas at work motivation for spending time on tasks and doing them well is often based intrinsically on personal work ethics, and extrinsically in producing a valuable

product or service. A more detailed discussion on assessment at university and in the workplace is presented in Section 8.3.

It is clear from this analysis of the students' reports of the different processes, motivations and values for learning that the settings of the university and the workplace offer, that the socioculturally-determined characteristics of the settings are critical in students' learning. It might be easy to conclude therefore that the students might see their learning in each setting as quite separate, and differently valued. Yet at the end of their degrees most students (15 out of 19) saw equal value in their placements and their coursework and felt that the placements were an integral part of their degree. These were the students who had reported that they had been able to apply at least some of their university learning to the workplace, or their workplace learning to their university coursework. Other students, Grant and Sally, who had not been able to apply much of their learning from one learning environment to the other, had indeed seen the placements as separate and the learning disconnected from their university learning. The students' perceptions of how integral their placements were to their degree stemmed directly from how much integration, how much applicability, they could see between their placements and their coursework. Where there was little integration perceived, the placements were seen as separate and unconnected to the coursework, but good integration led students to see their placements as integral to their degree.

To summarise, the students in this study learnt through their placements about differences in the practice of science and technology within the university and workplace settings, both at the practical and theoretical level, which affected their understanding of what it means to work in science and technology. Through their participation in each community of practice, they came to recognise the value of learning in each setting. Where the students were able to see integration between what they were learning in each community, they perceived their placements and their university study to provide them with an integrated education.

8.2.5 Summary of the integration of learning in two settings

The complementarity of learning in the placement and university settings was an important aspect of learning through their co-op degrees for students in this study. The students reported that prior to experiencing working in science and technology, they were uncertain as to how relevant and applicable their university-learnt knowledge and skills would be. Some believed that their studies would provide them with a base knowledge which would be built on at work.

In their placements, the students found that applicability of their university learning to work varied with the context of their workplace. The students focussed more on discrete knowledge and skills that they were applying, and where these weren't evident, they felt there was little application of their university learning to work. Those students who had viewed their university coursework as giving them a base for learning at work were satisfied that this had happened when they went on placement.

Learning in the workplace had influenced most of the students' subsequent studies at university. This influence encompassed both the learning of skills, changes in thinking and habits, and career decisions. Clear integration between their university learning and their workplace learning was important to the students in providing a link between the university and workplace.

The students in this study perceived the science and technology workplace as a learning environment but different to that of the university. These differences can be attributed to the sociocultural characteristics of each community of practice, encompassing the social relations, motivations, values and goals. Learning about these differences changed the students' thinking with regard to the practice of science and technology and led to a clearer understanding of what it means to be a practitioner in these areas. At the end of their degrees, most of the students felt that their university courses and their placements had contributed equally to their education in their co-op degree.

The next section explores students' views about how they felt their learning was assessed in the two sociocultural settings of the university and the workplace.

8.3 Assessment of student learning in two different sociocultural settings

As assessment is generally regarded as being intimately associated with learning in educational institutions (Tamir, 1998), it was important to consider how students in this study experienced assessment of their learning, and whether they felt the processes of assessment used, particularly in the placement, influenced their learning. The purposes for assessment in education have been described (Bell & Cowie, 2001) as formative – in which assessment occurs through interactions between the teacher and the learner for the purpose of improving teaching and learning during the learning: summative – in which assessment occurs, often through testing, in order to monitor learning progress, often in relation to peers and/or standards: and accountability – in which the purpose is to monitor educational standards. Bell and Cowie (2001) note that "both formative and summative assessment influence learning" (p. 7). They describe a summary of ways in which assessment influences learning as providing a motivation to learn through acknowledging learning success (or failure), by highlighting what should be learnt, by helping "students learn how to learn", and by helping students "to judge the effectiveness of their learning" (p. 7). Assessment particularly in tertiary education has also been argued to provide feedback to the learner and the educator, and provide students with motivation to learn (Bell & Cowie, 2001; Brown, Bull, & Pendlebury, 1997; Brown, Rust, & Gibbs, 1994; Miller, Imrie, & Cox, 1998; Rowntree, 1987). Recently, some authors have argued that assessment, particularly for formative purposes, can be seen as a sociocultural activity (Bell & Cowie, 2001; Gipps, 1999), which is integral to the teaching and learning process being situated in a context. This view allows consideration of a learner not solely as an individual, but as an individual within a socioculturally-determined world.

As the focus of this study was on students' learning in different sociocultural settings, it was of interest to gain an understanding of the students' perceptions of the influence of assessment in those settings on their learning. This section

discusses their general views on assessment in the university setting, and their views and experiences of assessment both during their placement and after the placement.

8.3.1 Students' views on assessment at university

Students in this study reported that assessment at university was important for gaining feedback on how their learning was progressing, and for providing motivation to learn. Many students (13/22) felt that assessment provided a measure of what they had learnt, and what they hadn't. They saw the assessment process as vital to indicate how their learning was progressing, and were supportive of regular assessments during their courses so that they could gain feedback on their learning as the course progressed. As Nancy said "it gives a gauge of how well you understand or how well you're coping with your courses" (Wo/1/4). Martin considered what it would be like to not have assessment, and commented "I think it is [important] because if you are not assessed then you don't have a guide to how much you actually know" (Ri/1/4). These comments indicated the students' need to test their knowledge and understanding in order to be convinced of its accuracy, and to make explicit to them that which they know. Without assessment the students felt they might not have the ability to gauge their own learning, and therefore be unable to redress any deficiencies as the course progressed.

This need for feedback on learning is characteristically met in the university setting within courses by regular tests and assignments, and within qualifications by exams. These assessments are summative, sometimes called continuous summative assessment (Bell & Cowie, 2001), in that learning is measured at a point, for the purpose of gauging student understanding, and are used to monitor progress, and count toward qualifications. There is often little or no feedback to the students other than a grade on these assessments, and the student draws their own conclusions on their progress and adjusts (or not) their effort or approach to their learning. Less common in the university setting is formative assessment. It does occur in some university settings, for example laboratories, field trips and tutorials, where class sizes are smaller and there are opportunities for one to one

interactions between the teacher and the student. In these situations there are opportunities for the teacher to appraise the students' learning and address issues to improve that learning. It is possible that formative assessment in these settings focuses on both knowledge and skills, seeking to improve learning in both these areas, but in my experience it is likely that knowledge development would be seen as more important by both teacher and student, as it would count more than future skill demonstration in any summative assessment at university.

Another reason for assessment in the students' (11/22) view was to provide them with a motivation to learn. Interestingly this reason appeared to be the most important for many students, as for those who mentioned both feedback and motivation as reasons for assessment, invariably motivation was mentioned first, and feedback was a subsidiary but still significant reason. Feedback has been argued to motivate students to learn (Bell & Cowie, 2001), and motivation is important to foster the deliberate activity that learning requires (Bell & Gilbert, 1996). In discussing how summative assessment motivated them to learn, a number of students used the word 'force' as though the act of learning was almost against their will and significant extrinsic motivation was required for the process to occur. For example Mike said "well it forces you to learn stuff I guess. It just makes sure that you do learn things, like it would be real easy just to cruise along, I don't know why you would ever turn up to lectures" (Mc/1/4).

The notion here appears to be that without assessment learning simply would not occur, because the student would not engage with the material. This is a somewhat frightening prospect in a tertiary learning programme, which the student had entered freely into, and indeed had paid for the privilege of doing so. It is possible that students such as Mike had undergone such a degree of socialisation into the learning/assessment process throughout their schooling, that learning had for them become a necessity in order to satisfy the assessment process, and this socialisation may have superseded any intrinsic motivation to learn (Lave & Wenger, 1991).

Victor gave a similar view to Mike, but added that assessment through doing assignments allowed him to actively engage with the concepts he was dealing with and to reflect on them, helping his learning:

> It *makes* [student's emphasis] me do something, because you can go to lectures and nod off and learn nothing. And then you get an assignment, and you find you have to know this, and you go through and learn it as you are doing it. When you're doing it, if you're writing and thinking, you tend to learn better I feel (Ro/1/5).

For Victor, the assignment provided him with a vehicle to work at his learning, and the acts of writing and thinking were significant for him in how he learnt. Victor found the passive, abstract environment of the lecture theatre not conducive to his learning, and needed to apply the theory to a task in order to facilitate learning. This has synergy with what students reported about the immediacy of their learning through the need-to-know environment of the work placement.

For other students like Lucy and Craig, it was studying for exams that 'made' them check their learning and clear up any lack of understanding. Craig commented that "the exams really make you study and make you take it all in, and try to take it all in. Bits you don't understand, you go and find out, because you have to. So I think assessment is a very important part of learning" (Su/1/6). In Craig's case, the preparation for the exams was an important reflection mechanism helping him to gauge his learning. The act of studying for the exam was seen to be as important, if not more so, as sitting the exam itself. Craig was adamant that he needed a structured form of feedback such as assessment in order to achieve learning. It is worthy of noting that Craig was not enjoying his courses at university at the time he made this statement, and this may well have affected his feeling towards learning and assessment.

None of the students in this study discussed assessment as a motivating factor in positive terms. It is possible that students might view assessments as a means of gaining positive feedback about their learning progress in terms of a reward leading to personal gratification. However, no student spoke of assessment

allowing them to 'show off' their learning and get good grades. It is difficult to say whether this is a genuine lack of concern about getting good grades, or a reluctance to express that interest for fear of being thought of as too studious.

In summary, the students in this study reported that assessment was important to them at university as it provided feedback on their learning progress, and motivation to learn. But what of the workplace? Did students encounter feedback mechanisms in their placements that influenced their learning? Did feedback in the placement help motivate students to learn? It is likely that opportunities would exist for formative assessment as the student worked under supervision, and therefore it is possible that regular feedback given by a supervisor may provide encouragement for student learning. In addition site visits by placement coordinators could help the student to analyse and reflect on how their learning was progressing, and suggest strategies to improve learning. The next section discusses what the students reported about assessment of their placements.

8.3.2 Students' views on assessment of the work placements

The assessment process used in the BSc(Tech) placement programme is multi-faceted. The students are assessed at the end of their work placements by means of a report that they write about their work, and by means of an evaluation of their work performance by their work supervisors. These two components count 50% each towards the grade given. Letter grades are awarded in line with the normal grading practice at the University of Waikato.

Site visits are also carried out by placement coordinators during which the student and their work supervisor(s) are interviewed. Data taken during these visits may be used to moderate the final grade. Students are informed of this assessment process prior to undertaking their first placement. As Bell and Cowie (2001) point out, the use of formative data towards summative assessment can place the student in a situation of risk, in that they may not be inclined to discuss their learning difficulties if they feel that a perceived deficiency may count against them in the summative assessment. It was of interest in this study to investigate whether the students expressed concerns over this dilemma.

This section describes students' views about assessment in their work placements. This includes both their experiences of assessment during their placements, and their views on the post-placement assessment.

8.3.2.1 Students' experiences of assessment during the placement

None of the students in this study experienced regular formalised assessments by their work supervisor in the workplace. Some students reported that they held regular meetings with their supervisor during which they would attract comments about their general work progress, but there was no mention of a structured assessment of learning. This contrasts with what the students reported about assessment in the university setting in Section 8.3.1, where continuous summative assessment was a feature of their courses.

Ten of the 22 students did report getting feedback on their work progress and their understanding of their work. The feedback was given in an informal manner, generally occurring during discussions about the work in a socially situated way. This type of feedback may be similar to that experienced by students in a university practical class. In general the feedback in the placement was focused on the completion of tasks. For example, in discussing feedback from her work supervisor Donna said "quite often he will give me work and I'll do it, and he will be really surprised at how well I've done it, or that I've done it so fast and he'll make me feel really good about it, which has been good" (Ni/2/11). This type of evaluative feedback was also reported by three other students, Kara, Kathy and Christine, and they also felt that it made them feel good about their work performance. None of these students mentioned that the feedback gave them an indication of what they had learnt, with the feedback apparently being more concerned with their work performance than their learning. These findings are consistent with the claim that learning in the workplace is subdued beneath the drive for productivity (Hughes, 1998), but it is also accepted that the students were learning in the process of completing the tasks. Therefore the feedback the students received may have been effective in promoting their increasing

participation in tasks in the workplace, with students learning through that participation.

One student, Joe, described how he had been receiving little feedback in his first placement so he took a proactive stance and asked for it. He said "I asked for feedback part way through to see how I was going, and they were very pleased. Because I set objectives and I wanted to make sure I was getting there" (Mi/2/15). Joe felt he needed to get some external assessment of his progress to date, in order to get a feel for how well he was achieving some objectives he had set for himself in the placement. From the feedback he received he was able to draw some conclusions about his learning progress towards his objectives. No other students reported being proactive in this way but a number reported that they received positive comments on their work from time to time.

Other students (9/22) reported that they got little feedback on their work during their placement. A typical response from these students was that they thought they must have been doing fine because they had had no criticism of their work performance. James commented that "they haven't yelled at me yet. They haven't dragged me into an office and sat me down and said 'look, lift your game'"(Sk/2/18). James took this as an indication that he was performing up to his supervisor's expectations. He was also aware that he was meeting deadlines with his project and this gave him an assurance that he was not under-performing. However, James reported receiving no feedback from his work supervisors on his learning.

One student, Lucy, reported that feedback she got was couched in flippant remarks about her ability. This caused her some anxiety, which was only relieved right at the end of her placement. She related:

> I didn't have a clue what [my work supervisor] thought of my work until yesterday when I dropped him off at the airport and he said, 'oh thanks for your help. You've been really good. In fact you've been an excellent worker'. Well I was kind of taken aback. I was like 'oh, cool, thanks'. So yeah that was basically the only feedback I've had from him for the whole eight months that he was here. He used to say, like if I'd make a mistake or I'd forget to do

> something in the test and then I'd tell him ... 'I forgot to do this, but then I did this to make up for it', and he'd always go 'it's so hard to get good workers around here' and 'if you've got to do anything you've got to do it yourself' and make all these kind of comments. He was joking but he said it so often that you really began to think, does he really think that? (Str/4/5).

Lucy worked independently for much of this placement and this may have contributed to the lack of feedback, as there were less opportunities for regular informal feedback. Lucy reported feeling a lack of confidence early in this placement, which only changed when she had proven to herself that she was able to carry out certain tasks through practice.

During their placements, the students were each visited twice by placement coordinators as part of the normal BSc(Tech) procedures. This would have provided an opportunity for the student to gain some formative assessment of their learning at work if the coordinator was able to spend time discussing the student's work and their learning. However, no students in this study reported receiving what could be interpreted as formative assessment from their placement coordinators during the latter's visits to them in their workplaces. Some students (4/22) noted some value in their coordinator's role in their learning, such as when Grant commented that his coordinator "gave me a couple of tips for my reports" (Be/4/13). Although it was not clear from Grant's statement, it may be that the report tips guided Grant's progress in demonstrating his learning through his report. The remaining students in the study (18) attributed no role in learning on their placements to their placement coordinators. This implies that an opportunity is being missed by the placement coordinators to practice formative assessment during the workplace visits to students, and to assist students to reflect on their learning while they are still in the placement. No students expressed any concern with the use of formative data collected during site visits for their summative assessments. It is possible that they did not recognise that formative data was being collected.

Clearly, the students experienced a different assessment environment in the workplace to that of the university. Viewed from a sociocultural perspective, asssessment in the workplace was more of a formative nature, and was based

more on factors such as work performance than directly on learning. The perceived amount of assessment or feedback given by work supervisors was variable, with often little or none reported received by the student. Students reported that they received little or no feedback on their learning progress. Feedback on what they had learnt was more likely to be by self-assessment through completion or mastery of tasks, or through informal and often indirect means, rather than any formal structure. It is likely that students gained feedback about their learning, through implementing their new knowledge and skills almost immediately in the workplace. This feedback may have been self-generated ('I can do this now'), inferred from lack of criticism of their work, or possibly by informal praise ('That's fine'). This situation is quite different to most learning situations at university where the learning of new skills and knowledge is assessed in an abstract way, often some time after the initial learning episode. This difference between learning and assessment at university and on placement may have contributed to students not recognising their learning in the same way as they might have been traditionally used to doing at university.

Indeed some students commented on how they really only discovered what they had learnt on placement when they went back into university-assessment mode in writing their placement report at the end of their placements. The report represented the summative assessment of their learning in the placement, and was combined with an evaluation of a number of their work-related competencies by their placement work supervisor to award graded credit for their placement. The next section explores students' views of this assessment they received after their placement.

8.3.2.2 Students' views about assessment received after the placement

In the BSc(Tech) degree programme the placements count towards credit-bearing courses. As such there is an institutional requirement to submit a grade for the placement course. All the students in this study acknowledged that their placement had to be summatively assessed as the placement counted as a university course. However there was a diversity of opinion about whether it was a good idea. Some students (3/22), like Donna, suggested that knowing that the

placement would be assessed would "possibly encourage people to perform more" (Ni/2/17). Others, like Joe, Jeff and Lucy, stated that getting a fair assessment across a wide diversity of placement opportunities would be very difficult, and that no assessment would be preferable (Mi/2/16, Rh/2/16, Str/2/14).

This latter concern is one that has plagued co-op programmes around the world, and no complete solution to the problem has yet been described. Many programmes in fact do not assess the placement because of the uncertainty brought about by this diversity of placements, and the inherent differences in learning opportunities. Other programmes assess on the basis of competency, giving a simple pass or fail grade to the student. Debate amongst co-op colleagues has raised the issue of motivating students to achieve their best in a system where there is no assessment or a pass/fail grade. This point has been countered by suggestions that students in placements with these forms of assessments will work hard to gain a good work record.

This study found that the students were indeed motivated to work hard by intrinsic factors such as pride and the desire to uphold their own, and the University's reputation. For example, Jill said " you have to impress, else these people might think you're a bit slack. I wouldn't settle for anything less from anyone else" (Le/2/5). No students mentioned that they were motivated to do well in the workplace by the possibility of getting a good grade, which is ostensibly the main reward for hard work at university. However a number of students (5/22) expressed happiness that they had scored a good grade in their placement, indicating that it held some significance for them. It is possible that although students may not be grade-motivated to work hard in their placements, post-placement assessments such as a written report may not be taken as seriously if a simple pass/fail grading was used, and there was no incentive to strive for a better grade.

In discussing the ways that they were being assessed on placement, students had mixed views about the mechanisms they would prefer that would best reflect their learning. As noted earlier, students in the BSc(Tech) programme are required to write a report about their placement as part of the assessment of the placement.

This report is ideally written towards the end of the placement and submitted about a month after the placement is finished. Students are given general guidelines on what their report should contain. While reports differ with the diversity of placements, they will generally contain a section describing the organisation they worked for, the work they did and how they did it, and some reflection on what they felt they learnt on placement.

Writing a report at the end of the placement as a good way to demonstrate their learning was supported by five of the 22 students in the study. For example, Nigel said "I think that is the best way. It is a less intrusive way. I can do my job and then afterward I can write a report and it's marked" (Gr/2/12). However, some students (6/22) expressed significant concerns about writing a report on their placement prior to and during their first placement. But after having done it, even though some still felt they didn't enjoy the exercise, all students stated that they felt it had helped their learning. As noted in Section 8.3.1, assessment can provide students with a motivation to learn. For example, the use of the report requirement put Grant back into the university-assessment mode, 'forcing' him to think about his placement. He commented that "it forced me to do a bit of research into the company, certainly get a bit of technical data and a lot of subtle things that I might have learnt, you know, sort of came to light when I wrote it down" (Be/3/7). Grant talked about how he realized that he had learnt about working with people and working in a team through writing his report (Be/3/7). Grant also mentioned later that he felt he understood the work that he had done much better once he had written it down (Be/3/7). In this way the placement report appeared to provide a vehicle for encouraging reflection, or self-assessment of learning, in the students. A number of students commented that the process of writing their reports helped them to reflect on what they had learnt. Karl noted:

> It's made me think a lot more about what I have done and then when I first started writing the second report, I was thinking I haven't done anything, I haven't learned anything, but with writing the report I learned that I have learnt things, the report helps a lot I think, you actually realise you have learnt something (Fr/3/12).

This reflection-on-action (Schon, 1987), or self-assessment of learning, was facilitated by the need to write the report. As Karl noted, before doing the report he didn't realise how much he had learnt. The lack of feedback during the placement and lack of previous encouragement to reflect on the placement meant that the report writing exercise was a revelation about their learning for students like Karl.

For Joe, the report that he wrote allowed him to bring together all that he had done in his placement and helped him get a better understanding of the 'big picture' in his placement. His view was one of guidance rather than force:

> I guess it helped me to reflect on the work that I'd done, because it summarised your method and everything that I'd gone through, it provided a very sort of concrete reinforcement of the work I'd done and where that would go in the future (Mi/3/9).

The process of writing it all down had given the Joe the chance to acknowledge what he had done and what he had learnt. It provided him with a summary of the value of his placement.

Finally in Jill's case, she was able to understand some features of her workplace that she had not realized that she had learnt about:

> It has allowed me to look back on it, and actually realise that I did actually notice the culture of the company, you know, I did actually notice the hierarchy and that those things actually affected the work place and how I perceived it (Le/3/10).

Learning about the culture of the workplace can best be achieved by participation in that workplace, and Jill felt able to understand, through the act of thinking and writing about her participation, how it had changed and hence what she had learnt. Jill spoke about the communication and the relationships at work, and the clash of egos amongst management. The report gave her the chance in a structured way to re-visit those experiences and to make meaning out of them and how they affected her work environment.

Some concern about writing a report for assessment was raised by a few students (3/22) who felt that some placements may offer better opportunities to write good reports than others. For example, Sally was unsure what she was going to write about, "because I have had such a mediocre placement" (Mo/2/7). Other students (10/22), such as Christine, said the report was a useful assessment tool but felt that assessment of their performance by her work supervisor was as, if not more, important in reflecting her learning:

> I think the reports are good because they give you an understanding. I don't know how you should, but I think when you're doing the practical job, I think maybe the supervisor's input should have been increased more than the report (Ha/2/16).

Christine and others worried that they might have done a great job, but be let down in the assessment process by their lack of ability to write a report. As Victor noted, "if I wrote a really bad report, that might be because I can't write reports, and not because I've done really bad throughout the placement" (Ro/2/18). These students felt that a written report may not be a fair reflection of their learning, as well as their ability to work. These students also noted similar concerns to those raised in the graduate survey (see Section 5.3.4) regarding having achieved learning in the workplace that could not easily be expressed in the report. For example, Martin noted that "what I've learned can be very hard to explain" (Ri/2/17), and that discussions with his supervisor would reveal his understanding better than a report might. These students felt that it was important their work supervisors could contribute to their assessment of the placement, as their supervisors could perhaps account for those hard-to-report elements within their particular community of practice. However, some students (3/22) were concerned about the work supervisor's assessment, worrying that it may not always be objective, and comparable to other placements. This has been an issue for all co-op programmes, and some programmes do not incorporate assessment by the work supervisor into the final grading at all.

In summary, students in this study felt that assessment of their placement was 'a student reality' as Joe put it (Mi/1/5). There were some concerns about how to fairly assess widely diverse placements, which may offer inequitable learning

opportunities. All students in this study found that the requirement to write a report about their placement provided an impetus to reflect back on their experiences. It placed the students back into university-assessment mode, in which external motivation of assessment requirement appeared to give them a vehicle for self-assessing their learning. The process of thinking and writing brought to their attention that they had undertaken learning on placement, illuminated features of their placement that they had not realized they had learnt about, and helped them to gain a better understanding of their placement experience. Some students were concerned that lack of perceived learning opportunities could impact on their ability to write a good report, and others were simply concerned about their ability to write, particularly about learning they felt they had achieved but was hard to express in writing. Some students felt that it was important that their work supervisors had an input into their placement assessment, but others were concerned about work supervisors assessing their work performance, in cases where personality clashes between the students and supervisor may occur, or in terms of getting consistency across supervisors. Despite these concerns, most students felt that these methods would give a good, or at least the fairest, indication of their learning on placement.

8.3.3 Summary of student views on assessment

Placements undertaken in a co-op programme are designed to be a learning experience. As the placements form part of a structured qualification they are generally subject to the same constraints as institution-taught courses, and assessment of learning achieved is a desirable and necessary requirement.

The students in this study held the view that assessment in their university courses provided them with feedback on their own learning, and a motivation to learn, in order to pass the course. For the students, regular assessments at university provided an indication of learning progress. These assessments can be categorized as continuous summative, as the assessment data contributes to final grades, and in many cases little specific feedback is given to improve and guide learning. Some formative assessment occurs at university within practical class, field trip and tutorial settings.

In contrast, students in this study felt they received little formal feedback about their learning in the work placement. Some students reported receiving what could be interpreted as formative assessment of their work performance, gaining appraisal of their completion of tasks that gave them confidence for undertaking future tasks. Other students in the study interpreted a lack of negative feedback received to mean that they were performing adequately. They reported gaining no other gauge of their learning from their work supervisor during their placement. These findings suggest that students received no summative assessment from their work supervisors during their placements and a variable amount of formative assessment, and that any assessment received is focused more on work performance rather than learning.

This leads to consideration of the role of curriculum in orientating students towards learning. In the university, the curriculum is set at the beginning of the course and the students are generally informed about what they are expected to learn, and (presumably) are assessed according to those expectations. Students are able to interpret their learning by their achievement in assessments, particularly summative forms. In the workplace, the curriculum for learning is much more uncertain. From a sociocultural perspective, it can be viewed as increasing participation in daily activities in the workplace. This has been termed a learning curriculum by Lave and Wenger (1991) containing a "field of resources in everyday practice" (p. 97). At the onset of their placements, the students in this study were expected to set some of their own learning objectives as part of the BSc(Tech) placement procedures. In my experience this has often posed difficulties for students in that they are not able to know clearly at the start of a placement about all the learning opportunities that they may be exposed to over the course of the placement. With such uncertainty about their curriculum, it is easy to understand how students on placement may not be able to interpret what counts as learning.

Without the summative assessment of achievement of (uncertain) curriculum objectives during the placement, students may have felt unable to gauge their learning progress, in a manner to which they had been accustomed in the

university setting. This difference in assessment of learning between the university and workplace environment may also reflect the different emphases each community places on learning. In the university, the emphasis may be described as learning for understanding and development and the learner is seen as an individual acting autonomously. In the workplace, the emphasis is on learning for performance and productivity towards the organisation's goals and the learner is seen as acting within the community. These differences have implications for students recognising assessment of their learning as increasing participation in the workplace and therefore understanding feedback they do receive for their own development, and for placement coordinators to counsel students to understand workplace assessment, and to counsel work supervisors to attend to students' assessment needs as they make the transition from the university to the workplace environment.

The site visit by the placement coordinator provided the opportunity for formative assessment but no students reported receiving any feedback or guidance on their learning from those visits. The study findings have implications for an examination of the role of the placement coordinator during site visits. Co-op programmes vary widely in the roles that they expect their coordinators to take. At one end of a spectrum the coordinator is merely a facilitator of employment between the student and the employer, a role that has been labelled a placement jockey (Mosbacker, 1969), and requires no active involvement during the placement. At the other end of the spectrum is a coordinator who is expected to take on the role of a teacher, encouraging student learning through active involvement during the placement (Coll & Eames, 2000). As noted above, the coordinator role for students in this study is closer to the latter end of that spectrum. As such the findings of this study indicate that for most students this role is not being successful.

This lack of assessment/feedback may have prevented students from fully understanding their learning during their placements, and indeed some did comment that they only really understood their learning once the placement was over. All students in this study commented that writing of the placement report helped them to reflect on that learning.

Assessment procedures during the placement were found to be less likely to influence learning for the students, as the motivation to learn was found to lie in factors such as personal pride and reputation. However, the report assessment after the placement did appear to influence student learning. This indicates that assessment motivates learning primarily within the university setting and less so within the workplace. This has implications for understanding the role assessment plays in co-op programmes, and therefore how it should be structured to reflect that role and the learning that students achieve.

Further to this, if no assessment were placed on the placement, the student would have no formal university mechanism in which to demonstrate achievement of, or gain feedback about, their learning. This may reduce their motivation to learn from their placement. As noted earlier the opportunity to demonstrate, or get feedback on, or motivation for, learning were three main reasons given by educators and students for having assessments. Without assessment, a risk is taken that learning in the placement would be ignored or under-valued, which runs counter to the goals of cooperative education.

8.4 Chapter summary

The complementarity of the learning environments of the classroom and the workplace is considered to be a defining element of co-op programmes. This analysis has provided evidence that the students in this study did experience integration of their learning between the university and the workplace, but has also shown differences between the two learning and assessment environments, and that the placement context was influential in the degree of perceived integration.

Students perceived that their learning at university and in their placements was integrated in a number of ways. They felt the placements provided opportunities to extend their knowledge and skills. Although prior to their placements students had thought they would use more of their practical skills than their knowledge, the experience on the placement altered this view. The students found that they used a limited range of skills learned at university but found that they greatly increased

their skill development through specific practice in the workplace, and that in fact their university knowledge helped them gain a greater understanding of the skills they were using. They felt that the practical work at university had only given them an awareness of skills, and the immediacy and repetition of use of skills in the workplace was more significant in their skill development. The students noted development of skills in laboratory practice and report writing as outcomes from their placements, which they were able to transfer back into the classroom.

The specific context of the placement was seen as important to the level of integration that the students perceived between university and the workplace. Where students were able to identify discrete knowledge or skills from one environment that they could apply to the other, they were more likely to see the environments as integrated. In some cases, students found it very difficult to make any connections between their university coursework and their placement as the work on placement bore little relation to their studies.

The students in this study found the learning environments of the classroom and the workplace to be quite different. They noted the different value placed on tasks and the motivations for completing tasks. In particular, the students noted the difference between practical science at the university, where process was seen to be more important, and the workplace, where process was still important, but outcomes were critical. This difference in learning experiences suggests that learning in the two environments of the university and the workplace should be viewed as complementary, a broader notion that may include integration of learning between the two environments. Acknowledgement of the context-specific learning opportunities in placements, and the differences in learning in the university and workplace environments holds clear implications for co-op programmes. These are discussed in the final chapter.

The students in this study also experienced differences in assessment between the classroom and workplace learning environments. Prior to their first placement, students felt assessment at university was about giving them feedback on the progress and providing motivation for them to study and learn. The assessment that they received at university was largely summative in nature. These students

had been enculturated into a particular assessment environment at university, in which their learning was assessed according to a pre-defined curriculum. However they met a different assessment and feedback environment in the workplace. In general they perceived that they received very little feedback in the workplace. One possibility is that they were unable to recognise the feedback they did get as related to their learning, as the students reported getting feedback only on their work performance, which could be interpreted as their progress towards participation in their community of practice. This more informal, evaluative type feedback is not often given to students at university level and this may have caused students to miss its significance in the workplace. This may have contributed to students gaining less of an understanding about what they had learnt in the workplace, as they may have lacked understanding of what counted for learning in the workplace. It is likely that students relied on self-assessment to gain feedback on placement. These findings have implications for preparing students for a different assessment environment in the workplace before they undertake their first placement.

The students in this study appeared more comfortable with the assessment procedures they were exposed to at university after the placement, which placed them back into an assessment environment more familiar to them. There was general assent amongst the students that writing the report had induced them to reflect upon their experiences and learning. However, there were some concerns expressed that the emphasis on report writing may penalise those students who had learnt a lot on placement but were unable to write reports. There were also concerns that the diversity of placements and employers may lead to inconsistencies in scope for good report writing and equitable employer evaluation. These findings have implications for consideration of assessment of the placement, which are discussed in the final chapter.

The final data chapter of this thesis presents two case studies that examine in depth how two students made their transitions between two different sociocultural settings towards becoming practitioners in science and technology.

Chapter 9 Results and Discussion

Case Studies: Becoming a practitioner

9.1 Chapter outline

One of the questions investigated in this thesis focused on what the students in this study learnt about becoming a practitioner in science and technology through completing work placements. Previous chapters have examined students' learning on placement from a sociocultural perspective, the significance of the science and technology workplace context for learning on placement, and the complementarity of learning between the university and the workplace environments. These previous chapters have drawn data across the student cohort and have sought to build a case for conceptualising co-op work placements as enculturation into a science and technology community through complementation of learning in the institutional classroom with learning in the workplace.

This chapter applies the sociocultural lens to two case studies, that each focus on the learning experiences and perceptions of one student from this study as they passed through their degree towards becoming a science and technology practitioner. The case studies aim to provide a richer and deeper view of two individuals' learning on placement and at university, highlighting the nature of their learning experiences that gave them a picture of what it means to practise in their field of science and technology. The case studies are focussed on the two areas of science and technology endeavour that were the most prominent in this study, one a public research environment and the other a private commercial manufacturing environment.

9.2 Learning to become a research scientist: A case study of Joe

Joe was a chemistry major in the BSc(Tech) degree programme. The following analysis includes data gained from a series of eight semi-structured interviews conducted at university and in his placements, and writings from a journal he kept in his first placement.

Joe is a New Zealander of European descent and was 19 years old when he entered the placement programme in his second year of university (Mi/1/1). He had enrolled at university in the year after finishing his secondary schooling, and had not held any full-time jobs other than summer vacation positions prior to attending university (Mi/1/10). He had moved to Hamilton, the site of the University of Waikato, from a slightly smaller city not far from Hamilton. His father worked in the technical trades and had some trade training, while his mother worked as a home keeper, and had no tertiary education (Mi/1/2).

Joe felt that his parents had had no direct influence on his choice of study and career (Mi/1/7). He also felt that he hadn't been influenced by any teachers at school to do science, although he did note that a particularly good chemistry teacher at school had developed his interest in chemistry (Mi/1/7). He attributed his interest in pursuing a career in science to a decision he made at school at the age of 15. He said "I sort of went through the process of trying to decide which sort of general area I wanted to get into. So I decided that science was an intriguing area for me and also it was an area where I was likely to get good employment" (Mi/1/7). Joe's perception was that he had made an independent decision to pursue a science career, based on his interest in science and his knowledge at that time of the career opportunities.

Although Joe had chosen a career in science he, like many other students in the study, struggled to explain what science is (Mi/1/8) (see Section 7.3.1). Prior to his first placement, whilst in his second year of university study, he compartmentalised science into the various branches that he could recognise such as chemistry and biology. This indicates a view of science that is constrained and controlled by his experiences of learning science couched in the compartments in which science teaching has come to operate, and had left Joe apparently unable to see a commonality that would allow him to explain what science is (Mi/1/8).

Joe was able to talk more easily about what a scientist does, depicting science as a process. He noted that "I see it essentially as a logical process of, of hypothesis, experimentation, and assembling the results and interpretation of those results. Just going through that entire scientific process" (Mi/1/8). Joe would have been

exposed to these practices to varying degrees during the course of his science education at school and at university, and had come to an understanding of science as a process of experimentation. This view could be interpreted as reflecting his school and university-based experience in doing science to date in his career.

Joe's view of technology was again typical of others in the study, as described in Section 7.3.2. Joe saw technology as an application of science:

> Well, technology for me is to take I suppose the knowledge that science generates, the how and the why and looking at how they can be applied to create something, a system or object that can improve the quality of life (Mi/1/9).

He saw technology as a process that uses scientific knowledge to create something tangible to improve the quality of life. He also saw technology as a process designed "to make money" (Mi/1/9). In Joe's mind, his own interest was to be involved in science that had a technological outcome. He spoke of his view that science and technology had "a symbiotic relationship" (Mi/1/9), and that one could not exist without the other.

These views were given prior to Joe's work placements. As he looked forward to his first placement in a research institute, he admitted to having no idea of what it would be like to work there, as he had not experienced it before. He hoped that his placement would help him understand what it could be like:

> I hope that I'll learn, or get a perspective of what it's like to work in a research environment, which is something that I haven't had at this stage and it will help me I think to decide what my future employment course is going to be. Whether I'm going to go, as I am looking at the moment, managing an industry site or to go down maybe the research avenue (Mi/1/11).

Joe hoped to get some clarification on his possible career direction through his placements by experiencing what it may mean to him to work in a particular career (Mi/1/11). The following section describes what Joe reported he did learn about working in science and technology in his placements.

9.2.1 Learning about the science and technology research work context

In his BSc(Tech) degree Joe had two three-month chemistry work placements over the summers of 1998-99 and 1999-2000. He worked in two different Crown Research Institutes (CRIs) in New Zealand. The CRIs are mainly government-funded and are individually focussed on a particular segment of New Zealand science research e.g., forestry, agriculture. Inaugurated in 1992, the CRIs compete for funding from the government-based Public Good Science Fund, but they are increasingly expected to generate income from private sector investment and commercialization of their science and technology work. Joe was placed within research groups in each of the CRIs he was placed in and worked as a research assistant, doing experimental work.

Joe's experiences working in a science and technology research environment led him to perceive some differences between learning about the practice of chemistry at university and in the workplace. He noted:

> At university it's structured, where you're being taught the theory in the lectures and tutorials, and then in the labs it's very controlled skills, they sort of feed you skills, a skill at a time as it were. [In the workplace] it's sort of bringing together all the relevant skills, teaching you how to use different machinery as it becomes necessary, and often you're making leaps forward from what you've learnt at university (Mi/2/15).

At university, Joe had had some practical experience of chemistry through his laboratory classes. The laboratory exercises that he had done were generally confined to demonstrating principles and particular techniques. Large class sizes and limited equipment often mean that undergraduates such as Joe are seldom given the chance to do practical research. The graduates generally come out of this training with an awareness of what tools and approaches are used in science research, but little or no actual experience in using them to do research. Joe emphasized how the controlled nature of learning skills at university, the feeding of skills, little by little, was opposed to the need-to-know environment that he encountered in the workplace. Other students in this study (e.g. Craig (Su/2/8) and

Sally (Mo/2/6)) had also commented on their learning at work being on a need-to-know basis, and how they saw that learning as more relevant and applicable than their university learning, as they were directly and immediately applying their learning at work, rather than harbouring their learnt knowledge for use later in an assessment task (see Section 8.2.4). Joe felt that immediate application of his skills in the workplace allowed him to make great progress in his learning. This type of learning would permit ready testing of knowledge and understanding and allow appropriate action to be taken to remedy any misconceptions or deficiencies to enhance learning at that time.

Joe had espoused an interest in the combination of science and technology prior to undertaking his placements. In both his placements he came into contact with science work that had direct and obvious applicability to industry. This was particularly the case in his second placement and Joe noted a difference between the type of research and researchers that he had previously observed at university and those he worked with on placement:

> I'm talking about the sort of technological product development that you get in a sort of an institute, that there's emphasis, at least this group's emphasis towards developing products. In the university we get exposure to people's research interests and most of the people I'm in contact with have more, I suppose, purist research interests and they're sort of more into pure research with a little bit of applied, but I'm coming into contact here with quite a lot of applied material, and I can therefore make the link between the chemistry theory and the technological practice (Mi/4.4/6).

Joe felt that the placement had shown him how chemistry theory could be applied, leading to product development. This was of great interest to Joe and he felt it showed him the relevance to his studies. His perception was that the research science that he had heard about in university had a different purpose to that which he had experienced in the workplace, indicating a difference in the two contexts. Earlier in the same interview he used the phrase "a sort of real world context which you could never get in a university" (Mi/4.4/6) when discussing his experience of the workplace. Joe made the point that he had been able to see how his university learning was applied in practice, and that he believed that the university was not able to teach him about the 'real world' in the way that the

workplace can. This would be particularly significant to students like Joe who hold the view that they will soon be entering that real world as a graduate. It was, he believed, the workplace context that gave him an understanding of what it means to research.

9.2.2 Learning how to research in a sociocultural environment

In his two placements Joe was immersed in scientific research for the first time. As a research assistant he was legitimately able to work alongside science researchers and become involved in the process of their work, albeit as a peripheral participant (Lave & Wenger, 1991). Through being given tasks to do, and his involvement in the science research community, he was able to identify some key learning outcomes. These outcomes included gaining an understanding of how to research, and to practise science. Joe commented about his first placement:

> It has been very good, it has certainly broadened my horizons of scientific research and has given me a good perspective of how science works in the workplace and also how it's practised and individual styles (Mi/2/3).

In describing the existence of individual styles in the practice of science, Joe indicated his learning that the community that he was on the periphery of was not homogeneous and that there were different ways to practice scientific research. He explained his comment on different styles as "I'm thinking about the approaches that different people take towards research, and the way in which they set it out and go about it, which does vary from person to person" (Mi/2/3). By working alongside science researchers Joe had been able to observe and participate in a variety of scientific research approaches from which he could develop his understanding of the research process. This exposure in a placement to different research styles could not easily be achieved at the undergraduate level at university, and could help a student to develop a meaning of the practice of research in science.

Through the social interaction of talk with members of the science research community, Joe learnt about ways to solve the research problems he was encountering. He emphasized the role that historical stories played in helping him understand the research process:

> The anecdotal stories that your supervisors give you about what they've done in the past, and the problems that they've encountered and that sort of thing, it helps you to sort of flesh out your idea of the research process and the way people do things (Mi/3/5).

Joe perceived that this sharing of knowledge by the 'old-timers' about their practice in science was important in his learning of what it means to undertake research. The use of the term 'flesh out' indicates a development process of coming to understand the way research is done. He noted that working alongside his workmates and supervisors helped "enormously" to contribute to his knowledge and ability.

In particular in his second placement Joe spoke (Mi/4.4/8) of how he would brainstorm ideas about research he was doing with his supervisor and they would work together on the direction that the work should proceed. This helped Joe learn about the steps that science researchers take in making decisions on how to make progress. This social interaction allowed him entry into both the knowledge and processes inherent in his science community.

Equipped with ideas, Joe explained (Mi/4.2/6) that he would then go back into the laboratory and get technical advice and instruction on how to carry out the experiments from his workmates. He came to understand that in a scientific research community there could exist a distribution of knowledge that had a potentially compartmentalized nature. As Vanessa had noted in her research placements (see Section 6.4.3.2), the scientists tended to direct the research, apply for funding, and analyse the data, whereas the technical staff were responsible for carrying out the experimental work. Joe could see how each group of workers contributed to the research process. As noted earlier in Section 6.4.3.2, Joe, and other students who completed placements in CRIs, learnt about the financial

constraints under which public good science is conducted in New Zealand. They learnt about the amount of time scientists spend applying for funding and how that funding influences the nature of the science research conducted. Joe noted the role that the social environment of conversations and meetings played in his learning about the impact of funding.

9.2.3 Experiencing the nature of research

Through his placement experiences, Joe reported learning about the nature of research. He was adamant that the opportunity to experience doing the experimental research for himself was critical to his understanding of what he was doing. He commented after his first placement that he thought that "the principal factor was actually doing it yourself, actually getting out there and doing the research yourself and then encountering the problems for yourself" (Mi/3/5). After his second placement Joe saw that his personal experience with problems and learning about problem-solving approaches from the 'old-timers' in his community combined to help him learn. This experience with engaging with problems gave Joe a clearer idea about the nature of research and the fluidity of its direction. He commented:

> It's sort of taught me that often the research can't be fully structured, like right from the beginning, with contingency factors having to be allowed for and often interesting sort of tangents might arise that are worth pursuing or can be pursued later. So it is sort of like a spider's web, if you like, of ideas and knowledge that have been generated (Mi/2/3).

It would be difficult to imagine how a student such as Joe could come to this understanding without being immersed in a research situation. No amount of tuition and description could substitute for a personal discovery of the intricacies of the research process. He talked (Mi/4.4/8) in his second placement about how he and his workplace supervisor would discuss problems and come up with possible solutions, and how he felt able to contribute more to these discussions as his knowledge and confidence grew.

In learning about the nature of doing research Joe encountered in his first placement an aspect to science that he had not been exposed to at university before. He wrote in his journal:

> I have found that it is quite common, at least in the group I am working in, to experiment quite loosely i.e. dabble, to try and see if different ideas will work before doing more structured analysis. Sometimes this trial and error process forms the basis for the experimentation and can throw up interesting results or new ideas that can be further investigated. This sort of work is helping to develop my investigative and experimental skills and is very interesting (Mi/J2/11).

For the first time Joe found himself in an environment where there were no clear end-points, no well-known answers to laboratory experiments performed by years of student classes. The exposure during his degree to this different way of working provided Joe with a chance to find out how he feels towards research before he commits himself to a career. It had the potential to be greatly disturbing and almost frightening as the comforting boundaries of classroom science are removed. In Joe's case it was a great stimulus as he remarked in his journal towards the end of his first placement:

> These new experiences have given me a greater appreciation of the research/experimentation process in action first hand and have generated in me a sense of excitement and a great deal of enthusiasm and interest, as I am at the centre of this research process (Mi/J2/4).

However, not all went smoothly for Joe, and the reality check was quite revealing for him. His placements showed him that "research seldom goes smoothly and that often there's a lot of frustration and things don't sort of go well or turn out the way you'd like" (Mi/3/11). Joe expressed surprise and annoyance with the frustration in his research work not going to plan. He added:

> It was annoying. I guess it was slightly surprising. I guess I would have liked things to have gone a bit more smoothly because when you're at university, the little labs are quite structured and they've been done before so things tend to go quite smoothly because of that (Mi/3/11).

This disturbance in thinking had created a perceptual change for Joe about how science proceeds. Having previously been exposed only to university laboratory work that proceeded as the class manual dictated, and 'incorrect and unexplainable' results had been rationalised by the instructor in terms of operator error, this new experience did not fit with Joe's constructs of what happened during science experimentation. As discussed earlier (Section 8.2.4), it points to a difference in student perceptions of purpose between university practical science and workplace science. Interestingly, at the end of his second placement Joe had developed strategies to cope with the research not progressing as expected:

> When it doesn't go smoothly your plans tend to collapse a lot, or part of them do, and you sort of just got to wipe those away and re-form a set of new plans to take you on. I always find that you have to think about 'what can I do next to further the research, keep the ball rolling?', because it's easy to get bogged down if things don't go right, trying to think of ways to get the ball rolling towards your goal (Mi/4.2/4).

This type of experiential learning, where Joe, in conjunction with his supervising scientist, was able to experiment, obtain results, reflect on those results, fit those results into previous knowledge and develop a plan for moving forward with further experimentation, can be allied with Kolb's (1984) model of experiential learning. This example of learning within the sociocultural context of the research institution, in which the student works alongside practicing scientists and gradually appropriates their practice, contributes to an explanation of the process of learning through cooperative education. The experiences that Joe had, led him to develop a view of what it means to practice in science and to become a research scientist.

9.2.4 Becoming a research scientist

Over the course of his degree and his work placements Joe felt that he had come to an understanding of what it means to practice research science. He felt that the combination of learning at university with the practice and participation at work had contributed to this understanding. He had been able to identify some key characteristics of the profession and had perceived that he had been at least

partially enculturated into its community. In the process of participation in the community he felt he had been able to construct an identity of a science researcher for himself (Hodges, 1998; Lave & Wenger, 1991).

In describing his development, Joe felt that he developed the skill of thinking like a scientist through doing his work. He wrote in his journal:

> When problems have arisen I have had to recognise and remedy them and have discovered where potential pitfalls lie e.g. pH adjustment of a solution [being 'canny' about where to stop addition of acid or base to get the right pH] and where in a synthesis it is safe to stop and store the product and which solutions/mixtures to retain and which to discard. In short I am developing the 'knack' of thinking in the way of experienced scientists/chemists when conducting an experiment /project (Mi/J2/5)

Through his experience at work, Joe had come to understand that there are 'knacks or 'tricks' that could be learned which would allow him to think like a scientist. As discussed earlier (Section 6.3.1), these 'tricks' are contextually based and often shared amongst a community of practice in a socially-situated manner. When questioned about how he had come to know that was how scientists think, Joe drew on a number of sources of inspiration. He said "I guess it was through asking questions, through my past experience at university as well, and I guess it was sort of finding it out for myself as I went and sort of worked out what were the best ways of approaching my projects" (Mi/3/8). Joe gave credit for his understanding of how scientists think to social learning within the context of work and from his own practice, but also acknowledged his learning at university, indicating his belief that both the work and university environments contributed to this development.

Joe also discussed how his skill base increased greatly through his experience at work. He talked about how the opportunity to practise skills in the workplace that he had originally learnt at university was important to him:

> Well I learned the basic theory through spectroscopy in the second year, in second year Chemistry and I was able to expand my

> knowledge of FTIR[5] and NMR[5], and electrospray, solid state NMR, just through practise and a certain amount of instruction on how to set things up and learning from [my workmate] and yes basically it has just been practise, practise, practise and that has certainly polished my skills. A year ago I just about didn't know what NMR was and didn't know how to read spectra (Mi/2/5).

Like other students in this study, Joe emphasized how the workplace experience had enabled him to 'polish' his skills and expand his knowledge. In this passage he described how his use of tools (scientific instruments) had socially mediated an increase in his skills and knowledge. He also discussed (Mi/2/5) how he had read journal articles (artefacts) to increase his knowledge and had then been able to go and test some of the methods that he had read about, which led him to a better understanding of what they meant.

In his second placement Joe talked about his development as a science student, perceiving a progression of learning from his first placement and his university courses. He commented:

> I would have to say I think I've learnt more here than I learnt at [my first placement]. I think the standard of my work here has gone up from what it was at [my first placement], basically through my experience there and in the intervening year at university, so I've been pleased enough but I actually seem to be contributing more ideas, doing more towards the research than I was at [my first placement]. [In my first placement] I guess I was a little wet behind the ears and they had to guide me a little bit more but here I can sort of say, no, no, I think this and this and these are more my ideas and they contribute theirs and we come out with a result we can use (Mi/4.5/9).

Joe described how he and his supervisor in his second placement would regularly discuss progress in the research and how he felt more and more confident to participate in the discussions due to his increasing knowledge and experience. His increasing participation in the research community led to the joint construction of new knowledge (Salomon & Perkins, 1998).

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[5] FTIR – Fourier Transform Infrared and NMR – Nuclear Magnetic Resonance are types of spectroscopy

Joe felt that he had gained a perspective of the part his placements had played in his learning to work in science. He valued his university education that he felt had given him the theoretical understanding of what he was applying in the workplace. He felt his placements had delivered to him a broader recognition of the application of his university learning to the 'real world'. He commented:

> I can see here the way in which the work that I've learnt in the university has been employed, and I can see the way people think and the way people develop products and ideas and technologies in a sort of real world context, which is something you could never get at university, and I think it's given me a very wide perspective on things, even though I've just been in CRIs, it's still given me a good idea of how science and technology is being applied. It's been essential to my whole learning development, it's highly recommendable to anybody in science and technology (Mi/4.4/5).

Joe was clear in his belief that the university study and the placements had complemented each other, and contributed to his learning in different ways. The integration of his learning from university into the workplace emphasized for Joe the applicability of what he was studying and provided a view of what it is like to work as a science researcher.

From these experiences Joe drew some conclusions about the characteristics of a good science researcher. Firstly he believed that he had learnt that one had to be passionate about the research in order to work in science:

> I think first of all you need a passion for what you are doing, an interest in the project that you are doing. I think that's important in any job, but particularly in science because things go wrong so often, almost 99% of the time it seems, so you've got to have the zest to just pick yourself up and carry on to the next avenue and try and explore that. And I guess it's that 1% of times when things go really well that makes it all worthwhile (Mi/4.2/7).

Joe, like other students who had worked in research placements (see Section 7.2.2), had come to understand that science research had a particular character, that required of its community a high level of interest to overcome the disappointments inherent in the process of research. It is perhaps only through the opportunity to work in a research situation that a student would come to know whether they are

suited to that type of environment, and therefore the chance to do so in a cooperative education placement may prove valuable in making career decisions.

Secondly Joe reached a conclusion about the need for flexibility and judgement to be a good researcher:

> I think a good researcher is a person who is flexible and is able to adopt new paths readily and quickly when they need to, but at the same time can work out how to most efficiently use that time within that environment of uncertainty. To try and judge which avenues of investigation will reveal the best results the quickest (Mi/4.2/3).

Through his experiences of participating in science and technology research practice, Joe had observed the modelling of flexibility and judgement by the science researchers. From working alongside science researchers who demonstrated their practice in a research science context, he had observed a variety of approaches, and from his own experience in that context within a community of practice, Joe had found his skill as a practitioner developing and his ability to contribute to the research progress increasing. By the end of his second placement Joe perceived that he learnt a lot about judgement in the science research process and felt that he had gone some way to developing into a science researcher. Cervero (1992) made the point that judgement is central to professional practice, and that "wise action means making the best judgement in a specific context" (p. 92). Cervero also noted that judgement is underpinned by the values of the community and that those values may vary between practitioners in the community, which resonates with Joe's observation of different styles of research.

The opportunity that Joe had to experience science research 'in action' left him in no doubt as to the career direction he was taking. These final words on the value he placed on his placements come from Joe's writing about his first placement:

> This placement has been a wonderful experience which has equipped me with a whole range of new experimental, analytical and social skills that will be of great help to me in future employment. It has also helped to stoke the fires of interest and

> enthusiasm within me for chemistry and I will enter this year with a much clearer perception of chemistry in action in the workplace (Mi/J2/14).

9.2.5 Summary of Joe's case study

Joe enrolled in a co-op degree programme because he hoped that the placement experiences would allow him to learn about what it might be like to work in science and technology research. After a total of six months work in two different science research institutes, Joe felt that his experiences in his work placements had complemented his university learning and given him a clear insight into what it is like to practice as a science researcher.

Joe found the learning environment of the workplace to be different from his university classrooms. He described his learning at work as a need-to-know style and as having immediate application to work. He found himself polishing skills gained at university through practice in the workplace, and was pleased to have experienced how his university-learnt theory could be applied in the real world, suggesting that for him there was integration of his learning between the two sociocultural settings of the university and workplace.

Joe's learning about how to research was mediated through instruction from workmates, discussions with supervisors, the use of tools and artefacts and his participation in the research process. He noted that he came to participate increasingly in decision-making that allowed him to move from the periphery of the community towards its centre. Joe learnt that research is complex, requires different approaches to those which he had experienced at university and is often frustrating. He learnt how knowledge and ideas are shared amongst the scientific community and observed how the community could be divided into participants who have different roles.

Finally Joe felt he developed some understanding of what it means to work as a science researcher. He identified some characteristics of a good researcher as a passionate and flexible person who uses good judgement based on experience. His description of how he developed thinking strategies that he considered scientific

from his placement experience, suggests that he felt he was being enculturated into the practice of science research. From his experiences Joe developed a perception of whether he could pursue a science research career. At the time of writing Joe has just completed his Masters degree in chemistry research, and is just about to embark on a PhD in the same area. It is impossible to say whether Joe would have taken this career route had he not undertaken the work placements that he has, but Joe is adamant that his work placement experiences gave him a much clearer idea of what to expect, enabling him to make a more informed decision.

9.3 Learning to work in a commercial manufacturing company: A case study of Jill

This second case study focuses on a student who completed all her placements working at the technical science level in commercial companies, and then secured a permanent position in her final placement company. Jill was an Earth Science major with an interest in environmental science in the BSc(Tech) programme. Jill was a hard worker, with a mature approach to her studies, that often led her to help her fellow students with their studies (Le/1/4).

Jill is a New Zealander of European descent and was 20 years old when she entered the placement programme in her second year of university (Le/1/1). At this point Jill had already completed one summer vacation of work in a local dairy manufacturing company at the end of her first year. Jill had had no other full-time work and had entered university the year after finishing her secondary schooling (Le/1/9). She grew up on a dairy farm and moved to Hamilton to attend university. Jill's father was a dairy farmer and was also involved in company management, and her mother was a teacher (Le/1/1).

Jill attributed her interest in science to her upbringing on a farm (Le/1/6). She recalls being told that she was annoying as a child because she always wanted to know why things happened. She felt that she was always going to study science, and saw her high school teachers as inspiring her to continue down the science path (Le/1/7). She still sought regular advice from one former teacher on what courses to study at university.

In her second year of university study Jill held a view of science that was similar to that described by other authors (Driver et al., 1996). Jill said:

> I think science is the understanding of the way things work, and why things happen. Understanding of stuff, why stuff, why the trees grow, why the grass doesn't grow in some places. And why we can make tables - you know it's just the stuff that I like to know about (Le/1/7).

Jill's emphasis on understanding how and why phenomena occur is also similar to the views of other students in the study (see Section 7.3.1). Jill also noted (Le/1/7) that scientists are people who try to find out how things work, and held the belief that there is a scientist in everyone. Jill's mention of making tables appears allied more to ideas about technology than science, although it is possible she was thinking about the scientific knowledge of the forces that hold the table together.

Jill's conception of technology focussed on improvement and being a means to an end and therefore also has some synergy with some authors (Driver et al., 1996; Gardner, 1995). She also saw technology as more recent than science:

> Technology helps you do things better than you did before. Because science was around always, it's just that technology has been getting bigger and better and faster and smaller. I look at technology as being a way of a means to an end. That's just getting more efficient and more applicable to things, just as we decide that we apparently need it (Le/1/8).

Jill conceived of the practice of technology as being development of a process or 'gadget' in response to human need. She saw technology as a growing area in comparison to science, and saw her own future moving more in that direction. Jill's view that technology is a more recent phenomenon compared to science is perhaps a reflection of the recent moves to separate science from technology in curriculum areas, making technology more of a recognisable entity (Ministry of Education, 1993, 1995).

These views were given after Jill had worked in a dairy factory over the previous summer but prior to her first official placement. She already had some knowledge of what it was like to work in industry from her previous experience but was looking forward to her next placement. During her second year at university she had won a scholarship from a dairy company which included work placements over the summer, and she went on to complete two placements in dairy factories.

Prior to her first placement Jill said (Le/1/12) she hoped to learn more skills in her placements in the programme. Her expectation was that she would be trained in particular skills, and then she would reinforce her learning with experience using those skills. Her focus was on gaining skills and experience to make herself more marketable to employers. Prior to her placements she was considering studying for a Masters degree in order to be competitive in the employment market, but was unsure about the financial commitment of further study.

Jill had two placements within her BSc(Tech) degree. These included a first three-month placement at the end of her second year and a second placement of eight months, which led into a permanent job. Both her placements were in the same dairy company, although in quite different sectors of different factory sites. Her first placement was working in a cheese development section and her second placement was in a wastewater treatment plant. The following sections describe what Jill learnt about working in science and technology in a commercial manufacturing company.

9.3.1 Learning how to work through social mediation and participation

For Jill, learning at work was a combination of social mediation, and the experience of participation. As noted above, prior to her first placement Jill felt that she learnt best by having skills demonstrated to her, and then for her to practice them. She was grateful for that type of learning in her first placement:

> I learnt a lot from my supervisors, just plain watch and learn. I found them really, really, really helpful, I thought they were very good teachers. Just the fact that they would like explain something and say, not only what you were doing but why you were doing it

> and how it fitted in to everything else, and then show you, and then stand there and watch you do it and tell you, 'yes that's right' or 'no that's wrong'. They wouldn't do it for you and then just expect you to do it, they would actually wait and make sure that you could do it yourself (Le/3/7).

This type of learning has similarities to the apprenticeship model. In this system the 'master' instructs the 'apprentice' and guides their progress until they are competent practitioners. Jill described how intense instruction in the early stages of the placement gave way to an increasing degree of independence over time in the job. Jill particularly noted the little things that they told her, that weren't written down anywhere, that helped her to carry out tasks. This socially shared knowledge is specific to the context in which she found herself.

Jill reflected on her own learning progress. She described how when she first began making cheese in her first placement she thought there was "no way I am ever going to learn all this"(Le/3/6). But then, as she comments, she did:

> I have noticed that when I first started I would forget things and I would have to look it up, and then, I remember, I suddenly realised that I hadn't forgotten anything and I haven't had to think about anything and I've just done everything, and they said obviously you've learnt everything. And I thought 'oh when did that happen?' What little point in time did I finally click it all into place? Because something I thought was really complex when I started is really simple now, and I didn't realise the transition (Le/2/7).

Jill's use of reflection-on-action (Schon, 1987) had enabled her to realise that she had learnt the steps of cheese-making, so that she no longer had to think, at least consciously, about the process. Interestingly, she commented that she "didn't realise the transition", indicating that the process of changing from learning to knowing for her was a seamless one. She felt that her improved confidence in her ability to undertake the task was important, as she said "that's why I try and think when I do it, well in three weeks' time this is going to be basic, so don't be scared of doing it now" (Le/2/7). Jill felt she had learnt to understand her own learning process and rationalise the feelings that she experienced when tackling new and complex tasks. The experience of having conquered the making of cheese gave

her confidence that she could master new tasks in the future, increasing her self-efficacy (Bandura, 1997).

In Jill's second placement she again noted the teaching that she had as important to her learning. This placement however presented different challenges. She was working in a relatively new wastewater treatment plant and there were many teething problems to deal with. She found her ability to problem-solve increased immensely during the placement and she paid tribute to the problems she had experienced for that. She commented:

> Because everything has been going wrong, I've learnt about a whole lot of different situations. Like if it had been all breezy from the start and I'd never been put in a situation when I've had to figure out what's wrong with something, then you know when something did go wrong I would have no idea where to start (Le/4.3/1).

The opportunity to experience 'real world' problems that could impact on commercial production was seen by Jill to be valuable learning. She felt that she had accumulated a lot of knowledge, however she noted that "it's not really technical knowledge, it's more like 'something like that happened to me a couple of weeks ago, and that time it was such and such, so let's check that'" (Le/4.3/1). These highly contextual problems had to be solved on the spot and required an experiential approach that worked on learning from past experiences, and adapting understanding gained from those experiences to novel situations. Jill described how the problems that she had had to overcome during the placement had given her the confidence to tackle new problems and feel comfortable with maintaining the treatment plant during her shift. She felt that she was better off than her workmate who had experienced less problems on his shift and therefore had less of an understanding about how to solve new problems.

Through a combination of learning that was socially situated, highly contextual and experiential, Jill felt that she had gained confidence in transferring her skills to novel situations. She noted that although each of her placements had given her specific technical skills that she was not able to use directly in subsequent work situations, the experiences had prepared her mentally to carry out new tasks and

tackle new problems. Jill had gained an understanding of her own learning and how she could use that learning in future situations. She reported:

> It's just the whole ability of knowing that you can go into somewhere and learn the skills required in a short time and be able to apply them. I would say the thing you learn is that when you go somewhere else you have a general understanding that is a lot higher than it would have been normally, so you don't have to start so low on the ladder, even though it might not be the same. It's easier to pick up (Le/4.5/8).

9.3.2 Learning about the commercial manufacturing work context

Jill's placements were in markedly different science and technology environments from those of Joe (see Section 9.2). In Joe's case, his placements were in research institutes and he was exposed to the practice of science and technology research. Jill's placements were in food production factories and by their nature the learning that she was likely to achieve in these arenas would be different. The food production factories are not as overtly science and technology sites as the research institutes. Jill was likely to be exposed to the application of science and technology theories and methods to the production of food, and the principal science and technology roles were likely to be production rather than research-oriented. Jill reported learning about the role that science and technology can play in a manufacturing plant, and the culture of the commercial world.

In her first placement Jill did find it difficult to understand how science and technology was involved in her placement. She could see that there was some science behind the making of the cheese, for example, in understanding that the pH of the mix needed to be right in order for the process to work. Her work was geared towards developing new cheese products and involved solving the problem of producing a new product by changing the 'cheese recipe'. She felt that her work was more typical of food technology, in that she was helping to satisfy customers' needs for an improved product, and that there was little science behind the work (Le/2/20). Although she valued the experience, she saw that the placement was not well integrated with her university study.

In her second placement Jill felt she could see how science and technology were involved in the wastewater treatment plant. She commented that "it's a science and technology site. Like here, we've got the science of how the anaerobic and aerobic plants work, but you've got the technology side of the entire plant plus all our monitoring systems" (Le/4.3/7). Jill saw the science as the understanding of the natural processes that occurred within the wastewater, and the technology was the process and machinery that were used to manipulate the wastewater through natural processes to clean it up before disposing of it in the local river. She noted the importance of the treatment plant to allowing the factory to continue to function, as wastewater pollution in the river could see the factory closed down. In this placement her work was more aligned with her university studies and she found herself drawing, albeit in a small way, on her university knowledge and some skills.

Jill's placement also gave her an insight into some aspects of the culture of working in commercial companies. She felt that work in these companies was driven by their motivation to make money, and satisfy management whims. In her first placement, the company she worked for was undergoing expansion to become more competitive. This led to plenty of talk in the workplace, as Jill commented:

> I think the thing I've noticed just generally is quite a few people have the opinion that all this sort of advancement is actually people promoting themselves, ego-type of thing. Like we've got to have a bigger drier than [the competitor]. It almost makes you think about where these people get their research from, to think that we're going to get 5% growth for the next ten years. No-one on the ground floor thinks that, so where do they get their research from (Le/2/9)?

Jill noted that she learnt about these opinions through social chat at work, particularly in the tearoom. Informal settings like the tearoom gave Jill the opportunity to learn how her workmates felt about their workplace, and she perceived that the workers held quite different views to those officially espoused by the company. Jill also recognised the operation of informal communication

networks when it became apparent that there was a possibility that part of the factory would close down during her first placement due to low supplies of milk. She experienced how the use of a 'grapevine' spread rumours and information around the company and led to changes in worker morale (see also Section 6.3.2).

What struck Jill most however was the behaviour of the company in her last placement as they sought to cut costs and to restructure. She described how the wastewater plant kept breaking down, due, she understood from her workmates, to a management decision to go with a cheap installation. She formed a negative impression of management from her experience and her discussions with her workmates. She commented:

> I'm getting very disillusioned with the bean counters who run the place. It's almost as if, it does seem to me being on the ground level, like they just sit in their offices and say 'the numbers don't look right, you have to get the numbers right and we don't care how you do it' and everyone back at the factory is just going 'sorry but we can't run a factory like that, like you're dreaming'. It's like this place [treatment plant], for an extra couple of million could have been made so that it would run perfectly well, and they went with a contract that was a couple of million less than someone put in, and they ended up being a couple of million over budget anyway. So it's like every day I go around and at least one sampler is not working, and I don't think I've had one day when I've got every single sample, because samplers break down so often, and it's like they bought the cheap samplers rather than the better ones, and it just makes it hard to, well it's like we are busting our gut to do it and everyone's screaming at us, but it's like everything down here is second-hand, handed down from the top of the plant. It's kind of like we are the [bottom]-end of the company and that's exactly how we get treated (Le/4.3/3).

These comments were given after just two months in the placement and convey a feeling of disenchantment with her employer. Jill felt she had learnt a lot about how commercial companies make decisions at the managerial level, which place the workers under pressure. She commented that if she was ever going to be a manager, "I'm going to try to do better"(Le/4.3/4).

Later in this placement the situation deteriorated further with restructuring of the company. The factory closed its monitoring laboratory while the staff were on

holiday, and then they restructured the middle management, including Jill's supervisors. Jill felt the company handled both exercises "appallingly" and that the processes used went against everything she had learnt about employee relations through a science and technology management course at university (Le/4.5/4). She described one point in the restructure process:

> They've got a big revamp with the managerial structure coming up and it was supposed to be on January 20 and then it was going to be last week, and they kind of called everyone in and they all expected pink slips, and then they said they hadn't made any decisions yet, so everyone is now saying that they don't care any more, which I think is a really cruel thing to do to your employees (Le/4.4/8).

Shortly after Jill made this statement one of her workmates left the company and despite her apparent negative feelings towards company management, Jill applied for and won his permanent job. This completed her transition from student to employee.

9.3.3 Becoming a commercial manufacturing company worker

Jill found that she gained more responsibility, more pay and opportunities for training when she made the transition from student to permanent staff member. She gained more time monitoring and maintaining the treatment plant and became a back-up person for treatment plants at other company manufacturing sites. Her remuneration increased and became more consistent due to movement from wages to a salary format. The training opportunities were very important to Jill as they allowed her to have more responsibility and carry out tasks without seeking assistance.

In Jill's view, she got the permanent job as a direct consequence of the experience gained on her placement. On the surface it seemed a little surprising that Jill had opted for a permanent job in the light of her comments about her disillusionment with management. But Jill had a pragmatic answer to that. She said she was "staring down the barrel of being unemployed anyway" (Le/4.5/5) so she jumped at the chance of a permanent job. Jill had been really enjoying the work and the

people she worked with on a daily basis, and she felt that being at the bottom of the company hierarchy was relatively safe. She noted that "at this point in time and in this company, I'd much rather be a so-called operator lackey than in management. I'd say middle management is a very risky place to be in a company like this at the moment" (Le/4.5/7). But she was also aware that the situation could change and she felt she had to "just make sure you don't take anything for granted and look carefully at where you want to go"(Le/4.5/7). Jill talked about the morale of the workforce being very low and that her workmates were on edge in case of more changes. Through these experiences of restructuring in the commercial manufacturing environment, Jill had learnt about their social and cultural impacts in workplaces. Exposing students to the possibility of these experiences through their placements has implications for preparing students for these eventualities, and providing support where necessary.

At the end of her degree and having secured a permanent job, Jill put her degree into perspective. Unlike Joe whose courses and placements were closely matched, Jill felt she had used only some of her university education in her placements, and had used virtually no learning from work back at university. Despite this she still valued her university courses and commented that "I'd say if I hadn't have done the university courses that I did, I would probably have found it a lot, not harder, but I wouldn't have an overall understanding as well as I do" (Le/4.5/10).

Jill credited her knowledge gained from a variety of her university courses as helping her to understand her work in her last placement. While she admitted that her work was very practically based, and that she had not learnt how to run a wastewater treatment plant at university, she had been able to apply theory that she had gained in her coursework. Partly because she had not had placements closely matched to her courses, and partly because her final placement had led directly to a permanent job, Jill placed more value on her placements than her courses. She commented:

> Well you kind of have to have the university stuff, but the fact is it's the work placements that kind of gets you your foot in the door. So everyone's probably been to university or has got some sort of qualification but if you can say that 'I have been to a job

> and I show up on time and I am reliable and I can learn new skills', you know, then that to me is not more valuable in my overall learning sense, but it's probably better for the job situations (Le/4.5/10).

In Jill's experience her placements had contributed most to her getting a job. She appeared to make a distinction between her university courses being valuable for the theory she had learnt, and the pragmatic view that the placement experience had given her the skills that had got her the job. In this case Jill's university study and placements had complemented each other in providing quite different learning opportunities, enabling her to secure a satisfying career position. This is evidenced by Jill's final words in her last interview in the study:

> Most of the time I'm so glad I ... I could go on and on about how much I enjoy my job here and so ... which to me is incredible, having gone four years at university, to actually come out and the first job go 'Wow, I like this' (Le/4.5/15).

9.3.4 Summary of Jill's case study

Through her work placements in her BSc(Tech) degree, Jill accomplished the transition between science and technology student to science and technology practitioner in a commercial manufacturing company. She was successful in obtaining a job in which she worked with science in a technological system designed to improve environmental processes, which fulfilled the interests she expressed prior to her placements.

Jill described how her placements helped her learn about practices in the workplace, and about how she herself learnt new information, giving her confidence to engage in learning in novel situations. She emphasised that her learning was socially mediated, highly contextual and reinforced through experience. Much of her learning was through instruction, embedded in the cultural and historical ways of working in the dairy industry. Over time her increasing participation in the practices of waste management in her second placement led to increased responsibility and enhanced understanding of the technical procedures in which she was engaged, making more central her role

within the community, eventually leading to complete acceptance into it as a permanent employee.

While Jill felt she learnt about science and technology practice through her placements, she also reported learning about the practices of the commercial world. She experienced the difficulties of working in a commercial environment where making money is the principal outcome for a workplace. She learnt about the way such an environment is managed and came to understand that although it was less than optimal, she could work within it. It would be hard to replicate this learning anywhere but in a real workplace.

Jill was successful in securing her first career position through her work placements, leaving her in no doubt of the value of her work placements. Her success in doing so changed her mind about considering doing a Masters degree. Unlike Joe's case, for Jill there had been little integration between her learning at university and in the workplace, yet she felt that the learning in each setting had complemented the other. At the end of her degree she placed more value on her work placements, but acknowledged that the combination of courses and placements had led to her becoming a science and technology practitioner in a position she enjoyed.

9.4 Chapter summary

These case studies of Joe and Jill's experiences in their co-op programmes have illustrated the transition that two students have made from science and technology students towards becoming science and technology practitioners.

These two students reported learning in their placements in a different way to learning at university. They found that learning at university was abstracted from application and motivated by an emphasis on process. In contrast they described learning at work as very applied and highly contextual and motivated by process and outcomes. It provided a 'real world' experience that they felt they could not get at university, leading them to a better understanding of the role of learning in the workplace.

The students reported the influence of the social and cultural environment on their learning. Their learning was socially mediated through instruction, discussion, the use of tools and artefacts and being enculturated into the community through immersion in practice. Equally important was learning through experience, both socially and personally. Experiential learning was seen to be particularly significant in learning how to do tasks and solve problems at work. Through being situated in an authentic practice community, the students came to understand what it means to practice science and technology in their particular work setting.

Finally, both Joe and Jill reported that they felt their university studies and placements combined to enhance their learning. The relevance of the placement to their university study affected the perceived applicability of knowledge and skills between classroom and workplace. However, less relevance of the placements to study in Jill's case did not negatively impact on her ability to secure a science and technology position that she enjoyed.

These cases have provided highly individual studies of development and learning that two students underwent through their co-op placements. They have permitted a view of how the accumulation of understanding and the process of learning on placement have contributed to the students' feelings of enculturation into their community of practice. The case studies have illustrated the sociocultural basis of learning about the practice of science and technology in the workplace, demonstrated by a range of observations from the approaches to research to impacts of organisational change. Lastly, they have provided clear examples of how the complementarity of university learning with learning through co-op placements has successfully enabled the transition of two science and technology students into science and technology practitioners.

Chapter 10 Discussion, conclusions and implications

10.1 Chapter outline

This thesis has addressed the issue of learning through cooperative education (co-op) work placements in science and technology. It has sought to make a contribution to knowledge and understanding of this issue through investigating two research questions:

1. What and how does a student learn through co-op work placements in science and technology?

2. What roles do the work placements in co-op programmes play in facilitating the transition from student to practitioner of science and technology?

Answers to these questions may help co-op practitioners with pedagogical and curriculum development of their co-op programmes, and provide some justification of the role of the work placement in the education of co-op students. A review of the co-op literature indicated a deficit in research addressing the question of learning on placements. A review of the learning theory literature suggested that sociocultural views of learning may be a perspective that could illuminate answers to this question of placement learning.

This study has interpreted student reports of their learning in their science and technology work placements, and examined how students saw that learning as complementing their learning in the university classroom. The study context was the BSc(Tech) programme at the University of Waikato, and it was a longitudinal investigation of a cohort of students as they passed through their degrees. Student reports and perceptions of their learning were gathered through semi-structured interviews and student journals. This data has enabled a picture to be built up, presented in Chapters 6 to 9, of learning that has contributed to giving the students a perspective on what it means to practise in science and technology.

This chapter draws together findings from this study, leading to some conclusions and implications. It begins by arguing that sociocultural views of learning have been shown to be useful in conceptualising learning in work placements. This is followed by discussion of student learning about science and technology on placement, and discussion of how students experienced the complementarity of their learning in the environments of the university and the placement. Conclusions are then drawn on the thesis. The chapter, and this thesis, finishes with comments on some methodological issues, and implications raised from the findings of the study for the future practice of co-op and further research.

10.2 Sociocultural views of learning on placement

Sociocultural views of learning have emerged from a variety of disciplines to explain the influence that social, cultural and historical factors have on learning. Two ideas appear to be particularly germane to this study: firstly the notion that learning is socially situated within a community of practice (Lave, 1991), and occurs through participation (Rogoff, 1995) in authentic activities (Billett, 1994b; Brown et al., 1989; Roth & Roychoudhury, 1993); secondly the concept that learning occurs through mediated action (Vygotsky, 1978) through the use of tools and signs (Cole, 1991; Wertsch, 1991a). This section argues that the data presented in this thesis indicates that these sociocultural views of learning are useful in understanding the learning that occurs in co-op placements. It argues firstly that student learning can be viewed as induction into the sociocultural setting of the workplace, and secondly that students' learning can be viewed as a socially mediated, situated and participatory activity.

10.2.1 Induction into the sociocultural setting of the workplace

Levine and Moreland (1991) describe the process of joining a new work group as involving learning about the group's culture, and being socialised into the group. Joining these work groups can be conceived through a sociocultural lens as induction into a new community of practice (Lave, 1991). Firstly, considering learning the work group culture, students in this study, who entered the new

community of practice of their placements, reported learning about the community's ethics, routines and other ways of working. For example, Rick's observations of his workmates' hard-working habits led him to an understanding of the work ethic in his first placement company. By being situated alongside these colleagues he came to appropriate their ways of working (Rogoff, 1995), in the process transforming his own practice to the practice of the workplace community. In other examples, Duncan and Donna discovered that the routines of working in their placements were new to them, and at first they found it hard to adjust from the different routines of the university environment. For those students who had had little previous workplace experience such as Rick, Duncan and Donna, their induction into a new sociocultural setting led to learning about what it means to be involved in a work community of practice. Other students in the study, such as James and Martin, who had had previous work experience, felt they had already learnt about work ethics and routines in their previous jobs, and felt that although they recognised that they were entering a new community, its parameters of work were familiar to them.

Secondly, students in this study reported being socialised into their communities of practice by building relationships through social interactions with community members. Prior to their placements, students such as Kara, Rick and Lucy had doubts about their ability to perform up to expectations, an issue discussed by Levine and Moreland (1991), and whether they would get on well with their work supervisors. These concerns about performance and relationship-building amongst the students indicated the importance to them of being accepted into their communities and led some to feel stressed in the early days of their placements. In particular, Martin's description of how he felt nervous entering his second placement despite having worked in many previous jobs was of interest. He made the point that he had not worked in research before and consequently he felt uneasy about what was going to be expected of him in his placement in a research community. In all cases, the students reported overcoming these concerns through development of good relationships within their work communities and gaining a better understanding of their abilities through participation in the tasks allocated to them.

The students in this study noted how their increasing participation in the activities of their work communities developed their confidence and interpersonal skills. For example, Craig noted that he learnt a lot about working with others through his placements, describing how he managed to cope with vastly different emotional circumstances at work. This experience indicates the use of his emotional intelligence (Goleman, 1996), as Craig described how he motivated himself to continue learning in the face of many frustrations. Goleman (1996) also noted the importance of empathy within the workplace, and Nancy spoke about how she felt it had been important for her to be in touch with her workmates' emotions in her placements. These experiences and the learning that ensued were mediated through social interactions as the students became socialised into their work communities. They indicate the impact that the affective domain may play in student learning in co-op placements.

Adopting a sociocultural view of learning has enabled students in this study to be seen as entering into a new workplace community of practice in their placements. The students have reported learning about the culture of working, which has implications for preparing co-op students with little or no previous work experience for entry into the workplace. Even students who had previous work experience reported concerns about entering a new workplace where the culture of work was unfamiliar. Prior to their placements, co-op students should be appraised of the general and specific cultural characteristics of the workplaces they are about to enter, and advised of strategies that would enable them to build successful relationships with the oldtimers in the workplace communities (Levine & Moreland, 1991), such that they will be able to acquire the knowledge and the skills to allow them to fully participate, and thereby learn, through their placements.

10.2.2 Learning as a socially mediated, situated and participatory activity

The research suggests that the notion of learning as a socially mediated, situated and participatory activity is a useful way to conceptualise what and how students learn in their co-op placements. Co-op programmes aim to place students into a work context in which they work alongside practising professionals, where they

undertake tasks commensurate with their abilities. In this way they are legitimate peripheral participants (Lave & Wenger, 1991), as newcomers who gradually move from the periphery of activity towards its centre, as they learn their work from workmates whose knowledge and experience give them status as old-timers.

The findings of this study suggest that learning in the placements can be seen as socially mediated, situated and participatory practice. Students spoke about how they learned how to do tasks and operate equipment through the social mediation of instruction. Salomon and Perkins (1998) described how this form of learning can be viewed as socially mediated individual learning, although they argued that this view tends to underplay the social contribution to learning, and that rather than the individual being seen to merely internalise knowledge, learning is seen more as transformation through participation (Rogoff, 1991). Much of this learning involved working one-to-one with an instructor who was knowledgeable, and had experience of context-specific tasks that was critical to the work.

A stronger social view of learning is described by Salomon and Perkins (1998) as "participatory knowledge construction" (p. 4), in which the individual and their learning "are seen as an integrated and highly situated system in which the interaction serves as the socially shared vehicles of thought" (p. 4). That this is a particularly useful view of learning in the co-op placement is shown by the comments of students in this study. In particular, Grant and Duncan mentioned that they learnt 'tricks' to get the work done, information that resided only in the heads of the practitioners and was socially shared. Similarly, Nancy and Lucy both spoke about ways of practice in their work communities that were not written down, and in which learning involved participation in the social construction of carrying out certain tasks. In this manner, students can become enculturated into their community of practice, sharing understanding about what they are doing and what it means (Lave & Wenger, 1991).

Additionally students in this study reported learning about the co-construction of new knowledge (Salomon & Perkins, 1998) in their communities of practice. Vanessa and Rick described learning about how the activities of community members meshed together to produce an outcome greater than any one individual

could deliver. Rick and Jill commented on how new knowledge entering the community got shared amongst the members according to the use each member could make of it. In this way social interactions provide for the distribution of knowledge across a community, such that knowledge can then become a part of the community. Conversely, Grant spoke about how he learnt that knowledge can sometimes be withheld and wielded as power within a community. This breakdown in the social sharing of information was seen to inhibit the participation of all members of the community in engaging in tasks.

Furthermore the students in this study reported learning about and through the community of practice at work. They spoke about the importance of talk in the workplace, through which they learnt about knowledge, skills and their workmates' feelings. From situations as diverse as a student and supervisor brainstorming ideas on how to progress a piece of research, through to conversations in the tearoom about workmates' worries about losing their jobs, learning could be viewed as legitimate peripheral participation within their community of practice (Lave & Wenger, 1991). This notion further moves concepts of student learning away from internalisation of knowledge and skills gained on placement to a view of increasing participation, as the student appropriates the ways of working in their community and constructs an identity as a member of that community. This implies that the learning in the placement involves development of what being a member in a science and technology community means, by being a participant within it.

This development of meaning through participation is supported by the finding that students who worked closely with scientists or technologists reported more learning on placements about the practice of science and technology than those who did not. This finding evokes notions of a cognitive apprenticeship (Brown et al., 1989), in which the student learns to use tools (such as scientific instruments and language) as a practitioner does. In particular, Joe noted learning how to research, and Jill described learning how to solve problems. They were learning through placement experiences in science and technology research institutes, through guided participation (Rogoff, 1995) with practising professionals. Through this engagement in authentic activities, the students may become

enculturated into the science and technology community, whose meaning and purpose are socially and culturally constructed (Hennessy, 1993).

The development of good working relationships at work was seen to be important in students' learning and gaining emotional support at work. The relationship with their work supervisor was reported to be a critical one, influencing student learning by the nature of the relationship. In a few cases, the relationship was reported to have characteristics that resembled the role of a mentor (Gibson & Angel, 1997; Ricks & Van Gyn, 1997). In these cases students reported great satisfaction with their learning and experiences on placements. Conversely, students who reported a poor or difficult relationship with their supervisor on placement reported less learning, a condition previously noted in supervisor relationships by Lave and Wenger (1991) and Billett (2000). This finding has implications for considering the key nature of the work supervisor's role in co-op programmes.

A further sociocultural construct of particular interest to this study is that of viewing learning as an activity mediated by tools and signs. This involves examining learning in the placement as mediated by students' use of tools such as language, and artefacts such as computers and technical equipment, which are themselves constituted in the social, cultural and historical environments in which they exist (Salomon & Perkins, 1998; Wertsch, 1991b). In this view, the context-dependent use of tools and artefacts enculturate the newcomer user into the ways of the community.

The findings of this study suggest that learning could be viewed as an activity mediated by tools and signs on placements. For example, many of the students (16/22) found that they had to learn a whole new language of technical terms, abbreviations and acronyms in order to carry out work within their placement community. They learnt the new language through social interactions and socially-derived documents such as journal articles and in-house manuals. The newcomer students expressed feelings of frustration and confusion when first confronted with the new language, and felt that they remained truly on the periphery as they could not understand the meanings within the language, and

therefore how the functioning of the community was organised. Grant's experience was typical, creating feelings of inferiority and isolation when he couldn't understand the language being used to instruct him in his work. The students described how they felt more accepted and included in their communities at work once they had learnt it. Lave and Wenger (1991) made the point that learning how to talk in the manner of community members is important for newcomers learning to be more central participants in the community. In my own experience as a co-op coordinator, upon visiting students in their workplaces towards the end of their placements, I have been struck by the students' usage of language unfamiliar to me, which when I questioned them was revealed to be community-specific terminology that the student then had to patiently explain the meaning of to me. I was the newcomer becoming enculturated into the community's language by my student as a legitimate participant. As Nancy's example showed, this specialised language can sometimes take on a life of its own, in which community members freely use terminology, of which they cannot remember the meaning, or at the very least the origin. These findings have implications for preparing students for placements by discussing the role language may play for them as they enter their new community of practice, and to understand how their learning experiences are shaped by their exposure to new language through the site visits and the assessment of the placement.

Enculturation into the community was also reported to occur for students in this study through learning about the use of technical equipment, and artefacts such as the dress code and company icons. Students noted how learning to use technical equipment such as scientific instrumentation showed them the role that the equipment played in the work of their community, the understanding growing with prolonged engagement with equipment. Learning to use equipment also showed them the value the equipment had to their work, which became particularly evident when the equipment broke down. The use of technical equipment specific to the community of practice is embedded in the social and cultural functioning of that community. This was typified by Lucy's comments about her use of the HPLC[6] in her placement. She noted that she had only seen an

[6] HPLC – High performance liquid chromatography

old instrument at university prior to her second placement, yet as she was enculturated into its operation through intensive use of one in her placement, she came to understand its role in the work in which she was involved, and indeed became the expert who subsequently enculturated other community members into the operation a new machine.

Through learning about the dress code, students gained an impression about the professionalism, attitudes and values of their workmates. The students' learning was mediated by the artefact of clothing, providing them with a sociocultural guide on the norms of behaviour in the workplace. In a similar way, company icons such as awards displayed in corridors provided students with an understanding of what was valued in their placement organisation. The students felt these mediations helped in their understanding about what it meant to work in their communities of practice.

Conceptualising learning as mediated by technical and psychological tools (Wertsch, 1991a) has shown to be useful in examining student learning in co-op placements. Regarding Vygotsky's (1978) understanding of the social role of such tools, Wertsch (1991a) claimed that "they are products of sociocultural evolution and hence, are inherently situated in sociocultural context" (p. 91). These tools, both language and technical instrumentation in this discussion, allow knowledge and understanding to be distributed across the community (Pea, 1997). These tools may also delineate the borders of the community (Cole, 1991), requiring them to be learnt in order to facilitate a border crossing (Aikenhead, 1996) into the placement community of practice.

In summary this study has found that sociocultural views of learning are useful for conceptualising student learning on work placements. This finding then responds to the need expressed by Gardiner and Singh (1991) for examination of the impact of social and cultural interactions on placement learning. It also responds to the calls from Ricks et al. (1990) and Stull et al. (1997) for a theoretical framework that could help explain cooperative education as a learning strategy. In particular, this study has found that student learning on placement can be viewed as a socially mediated, situated and participatory activity. The opportunity for a

student to work alongside practising professionals in a science and technology workplace has contributed to their enculturation (Hennessy, 1993) into the socially shared community of practice (Lave & Wenger, 1991). The placement can be conceived of as a learning environment in which the student appropriates social-cultural-historical knowledge and skills (Billett, 1998) but also participates in the joint construction of new knowledge through social mediation (Salomon & Perkins, 1998). This social mediation involves the student constructing an identity as a member of that community of practice, through the social negotiation of activity with workmates, their language and their artefacts, through which the student constitutes a meaning for their own practice within the community. Therefore co-op students entering work placements could be viewed as apprentices, or legitimate peripheral participants. From this view these students may be seen to learn as they come to increasingly think and behave like the science and technology practitioners around them, in the process constructing for themselves an identity within the community of practice (Hodges, 1998; Lave & Wenger, 1991). These findings contribute to an understanding of what and how a student learns on a co-op placement. Therefore sociocultural views of learning are useful in considering the pedagogy and curriculum for cooperative education. This has implications for designing a teaching curriculum and pedagogy to prepare students for their work placements, and for assessment of the learning outcomes of their placements. These implications are discussed later in the chapter.

Adopting a sociocultural view of learning has also proved useful in examining what students learnt about the discipline of science and technology and this is discussed in the next section.

10.3 Learning about science and technology in the placement

In Chapter 7, student perceptions of their learning about the practice of science and technology in the workplace context were examined. What emerges from that examination is that student learning about science and technology on work placements is context-dependent, being mediated by social interactions, and engagement in authentic activities in a community of practice. In particular,

students reported learning about what it was like to work in three different New Zealand science and technology contexts, about the practice of science and technology in the workplace, and what science and technology skills and knowledge can be learnt.

The students in this study were placed in one of three different science and technology contexts: private commercial/manufacturing companies, public research institutes or local government organisations. Students reported learning about particular characteristics of these different workplace communities and the type of work that is undertaken within them. Through their engagement in everyday activities in these workplaces, the students came to understand the parameters within which the type of organisation exists, such as funding for research, deadlines for production and the significance of dealing with the public. The meaning they ascribed to those parameters was developed through the students' participation in activities that were affected by the parameter, and social interactions with their workmates. For example, students learnt about the parameter of funding in research through conversations in their workplaces about the need for money for research; they learnt about deadlines for production and the significance of dealing with the public through being involved in the process. Through these experiences the students developed some understanding of how science and technology is practised in particular types of organisations in New Zealand.

Students in this study also reported that they learnt about the practice of science and technology in the workplace. Their learning was contextualised by the work in which they were involved, and this work, and the environment in which it was conducted, confirmed and extended their prior views of science and technology practice. Through participation in the daily activities of science research or technological development, the students developed an understanding of how science and technology are applied in what they described as the 'real world' of work. They reported learning about the time-consuming and sometimes-frustrating nature of science and technology research, and about how it is driven by funding. The students noted the rapidly changing nature of technology practice and the need to keep up with the market. Where these students identified their

work as involving science and technology practice, they appeared satisfied that they were learning. In cases where students felt they were not able to participate in what they saw as scientific or technological processes at work, they felt their learning opportunities were restricted, regardless of the activities that may be operating elsewhere in the workplace. Lave and Wenger (1991) made the point that participation "in a legitimately peripheral way entails that newcomers have broad access to arenas of mature practice" (p. 110). The lack of access reported by these students may have prevented their becoming legitimate peripheral participants, at least in their own eyes, if not in the eyes of their community. This has implications for a consideration of the participation that can be expected by students, placement coordinators and the employers. Less than clear description of expectations by any of those parties could lead to confusion and disenchantment with the placement.

Additionally, students reported learning science and technology knowledge and skills in their placements that were related to their work. By dint of the tasks in which they were engaged, the students learnt technical knowledge and technical skills that allowed them to carry out their specific work tasks. This included the use of specialised analytical instrumentation, laboratory and field equipment, computer programmes, and information sources. Skill learning was socially mediated through instruction and co-construction of understanding of how to perform tasks. Knowledge was learnt particularly through scaffolding (Salomon & Perkins, 1998) by cultural artefacts such as peer-reviewed journal articles or, increasingly, internet sites. These artefacts act as tools that mediate the social sharing of knowledge across the community, and which students gain access to as legitimate participants researching a subject jointly with others.

Finally, the opportunity to participate in science and technology communities of practice contributed to students' learning about their career options. Students in this study stated that they chose to do placements in order to learn more about a possible career, and all students reported being influenced in their career thinking by their experiences on placement. This finding agrees with previous research on co-op placements (Dubick et al., 1996; Eames et al., 1996; Somers, 1995; Wessels & Pumphrey, 1995).

In summary, the findings of this study suggest that co-op students learnt about science and technology through work placements. This learning encompassed gaining a perspective on the operation of a science and technology organisation, learning about the practice of science and technology in the workplace, and developing specific science and technology skills and knowledge. Adopting a sociocultural view of this learning was useful in thinking about how meaning was created for the students about the practice of science and technology in the workplace, and their possible career within it.

Much of the learning about science and technology on co-op placements is specific to the particular workplace, but the learning can be viewed as complementary to student learning at the university. This is discussed in the next section.

10.4 The complementarity of two different learning environments

Whilst the work placement is what sets co-op qualifications apart from others, an important related notion is that learning in the placement should be integrated with learning in the classroom (NZACE, 2003), in order to be relevant to the students' studies. This study has found that the students believed that learning does occur when the placement integrates well with their university study.

The previous section summarised the finding that students reported science and technology learning on placement that was context-bound. In the same way, the context of the placement determined the level of perceived integration between the placement and the university classroom. Where students felt they could apply learning from one environment to the other, they were more likely to see the environments as connected. In many cases, these students felt that they were applying only a small portion of their knowledge and skills to either environment, recognising that the generality of their university learning was only likely to overlap in certain ways with the specificity of their learning in the workplace. However, in 25% of student placements studied, students saw no connection between the two environments because they felt their learning in each place was

not relevant to the other, and that they could not apply learning from one environment to the other.

These findings hold clear implications for co-op programmes. In order to justify the relevancy of the placement as a learning opportunity within an academic qualification, these co-op students expressed a need to perceive some relevance of the placement to their university study. A student's learning opportunities in the placement will be dictated by the sociocultural nature of the workplace in which they are placed, by their learning curriculum (situated opportunities) (Lave & Wenger, 1991). Firstly, this places an onus on placement coordinators to understand the nature of the workplace and to match placements with student interests and classroom study as closely as possible. Naturally there are constraints upon this matching process, such as a lack of suitable positions or unrealistic student expectations, and where these constraints prevent good matching of student to placement, responsibility falls upon the coordinator, or other facilitator of student learning on placement, to enable the student to make links between their classroom learning and their workplace learning. This role needs to be fulfilled through contacts such as site visits and post-placement discussions.

Secondly, it should be recognised that the student on placement may achieve learning which is entirely new and not easily relatable to their classroom studies. Yet this learning may make a significant contribution to a student's learning about the meaning of working in science and technology in that particular community of practice. This learning may then complement, rather than integrate with, the classroom learning and contribute to a broader education than could be achieved by classroom learning alone. In particular, the students in this study found the learning environments of the university and the workplace to be quite different. These differences have been raised previously by Hughes (1998), but whereas he saw the differences as barriers to effective learning in the workplace, the students in this study did not. In particular, within the university the students conceived of their learning to be abstracted from reality, with its purpose being primarily to satisfy assessment towards their qualification; they felt their learning was asynchronous to its application; they reported that most of their learning occurred outside the 'classroom' through study at home, and that attendance in the

classroom was to gain direction on what to study rather than learn; they conceived of their learning in practical skills to be focussed on the processes they were involved with, and that the outcomes of their practical work to be of less relative importance; and they felt that the emphasis in university practical science on demonstrating principles and practising skills reduced the need for a successful outcome.

In contrast, in the workplace, the students found their learning to be highly specific to the task at hand, and tightly synchronised with its application, a point that had previously been made by Resnick (1987). In other words they learned what they needed to know when they needed to know it and used that knowledge immediately. Learning occurred in the 'classroom' – the workplace where tasks were undertaken – and less so at home (although some students reported that they undertook more learning for work as they increased their participation in their workplace community). This finding concurs with Cervero's (1992) assertion that professional practice in the workplace is situated in time and context, and oriented towards action.

The students also found themselves learning skills in which learning the process was of equal importance to the outcome of its use. Therefore the students, who believed that they had been educated at university to not be concerned with outcomes and to focus on the practice of the skill, were now faced with an environment where the outcome of their practical work was critical. This difference has implications for consideration of how students are taught at university, and reflects the notion expressed by many students in this study that they did not see their learning at university as representative of the real world. These findings indicate a move towards a practice of science and technology in the classroom that more closely matches the workplace would enhance student understanding of what it means to be a scientist or technologist. The findings also raise implications about how students make that transition in their practice from student to practitioner, and from the point of view of the classroom, how the students are taught and how they are assessed.

Furthermore, the distinction between the importance of process and outcomes creates a fundamental difference between the workplace and classroom environment, which could cause a tension for student learning. A workplace environment with a primary focus on outcomes can compromise learning about process, as the drive for production may reward outcome and reduce the scope for, and acknowledgement of, learning about process (Cornford, 2000; Hughes, 1998). Those placement environments which are commercial outcome-driven, such as manufacturing companies, potentially afford students less opportunities to learn about how and why tasks are carried out, preferring to use them as simple productivity units, and this was experienced by some students in this study. These students were placed in a production environment in which they gained little opportunity to learn other than how to conduct a repetitive task leading to the all-important production. This tension between learning through process and the demand for production in these types of placement environments necessitates a reconsideration of what students can learn through their placements. This has implications for facilitation of learning opportunities for students placed into these types of environments. If students are to be placed in these environments, due to their interests, or constraints on more suitable placements, careful monitoring of their learning would be important to either ensure access to a range of authentic activities (Billett, 2000) or, if this is not possible, to orientate the student to learning opportunities in the workplace that are less connected with the direct task at hand, such as knowledge of the industry and development of personal skills. Both students and placement coordinators will need to understand what learning is required for students to move beyond being peripheral participants in this type of community of practice (Lave & Wenger, 1991).

This study's concern with student learning includes an interest in assessment, and here again the students experienced differences between the workplace and the university environment. In the university environment the students had been enculturated into a world in which summative assessment was the main tool used to examine learning. Students used this assessment to monitor their learning progress and to provide motivation for their learning. Being used to this style of assessment, students perceived that they received little or no feedback on their learning, as they received no summative assessment in the workplace

environment. Students did report getting some feedback on their work performance by way of informal and irregular comments from their supervisors. This can be interpreted as formative assessment, a style of assessment which students (in particular in science and technology) get less of at university. This finding may indicate that students do not recognise this less formal feedback as assessment as they are not accustomed to receiving and interpreting it. Students felt that owing to a lack of perceived feedback, that they relied more on self-assessment of their own judgement and learning, a development that may enhance students' lifelong-learning skills (Cates & Jones, 1999). This implies that it may be necessary to prepare students for a different assessment environment in the workplace before they undertake their first placement, one in which they develop more autonomous feedback mechanisms.

Related to this finding are the views that students raised concerning the summative assessment employed by the university for the placement. Two views were particularly raised by the students. Firstly, that a summation of what a student has learnt through their placement in a written report may not be a fair way to express the learning they were able to achieve. The students noted that a written report may not adequately allow them to demonstrate the knowledge and understanding of the practice of science and technology that they had gained; that some placements offer more science and technology to write about than others, and that students who perceived that their learning was restricted to routine procedures felt disadvantaged. These findings have implications for consideration of assessment of the placement, in that whatever assessment tool used should acknowledge the different learning environment of the workplace, and that each workplace community of practice may offer different learning opportunities. Such consideration would allow better acknowledgement of those students whose learning in the complementary settings of the classroom and the workplace have left them well-suited to make the transition from being a student to being a practitioner.

Secondly, the students noted that the process of reflecting upon the placement for a summative assessment (written report) had encouraged their analysis and interpretation of learning. Many students commented that it was only through the

report writing process that they understood what they had learnt from their placements. This finding implies that a summative assessment tool can play a valuable role in encouraging reflection on practice (Schon, 1983) leading to learning that may not otherwise have occurred.

In summary, this thesis argues that that the findings of this study show that co-op student learning in the two environments of the university and the workplace should be viewed as complementary. This notion allows for integration of knowledge and skills between each environment, but also acknowledges a unique contribution to student learning that is made by participation in each community of practice. This uniqueness is delineated by the differences in the learning and assessment processes within each community, which a co-op student needs to be enculturated into in order to be successful in a co-op programme.

The next section comments briefly on some issues of study design before conclusions are drawn on the study and implications are raised.

10.5 Critique on the use of method and study design

The use of different data collection methods in this study has raised some issues. The two main methods used were the questionnaire and the interview. Advantages and disadvantages of each method were experienced in this study.

The use of questionnaires for the graduate survey worked well as a method for gathering data from a large sample. The response rate was high at 77%. The instrument was able to gather data from closed questions that could be analysed quantitatively, providing opportunities for statistical interrogation of the data. Each participant had the opportunity to respond to each question, and to spend time considering their response, providing consistency and allowing for the possibility of a more measured response.

However, the questionnaire method also showed some disadvantages. It provided some unclear qualitative data from the open questions. This data lacked clarity in addressing the question and in its use of multiple terminologies. The use of mail

in administering the questionnaire prevented any opportunity to clarify these unclear responses. A further disadvantage related to the study design. The questionnaire was used to gain retrospective views from graduates of the programme. Two issues arise from this: firstly it is possible that graduates' views of their learning from their placements had been affected by the passage of time and subsequent experiences; secondly the questionnaire stipulated that respondents consider only the last of their work placements when responding, and it is possible that graduates were not able to remember clearly what they learnt from each placement, or that they were unable to include important learning from earlier placements in their response. The use of the longitudinal study design for the main study went some way to overcoming these issues.

The other main method of data collection was the semi-structured interview. This method allowed in-depth exploration of issues raised by students and immediate opportunities for clarification of responses (Jaeger, 1998). As noted in Section 4.5.7, while every effort was taken to minimise any perception on the students' part of concern between my role as a co-op placement coordinator, and as a researcher, it is possible that some students were not as open as they might have been due to these concerns. The interview format placed such students in a compromising situation owing to possible perceived power differences between myself and the participants (Erickson, 1998). While I believe this issue was not prominent in this study, it does indicate a difficulty with this method when the researcher is intimately associated with the context being researched.

Some observations can be made regarding the longitudinal study design. Firstly, the use of multiple interviews with each participant over a period of time did elicit information about changes in participants' thinking, and permitted any reflection by the students to be examined. Re-visiting previously-stated views in subsequent interviews allowed participants to confirm, modify and even totally alter their espoused views in the light of their experiences since making that earlier statement. Despite this, each interview could only access students' perceptions at that moment of time, and it is possible that students found it difficult to recall all the learning changes that they had undergone. Adopting a case study approach during the second placement, in which data was collected by interview several

times, did result in a richer picture of student learning. A possible way to improve understanding of learning development in the placement would be to use participant observation (of a small number of students) in combination with interviews to examine learning over time within a context. Participant observation was not employed in this study due to logistical and procedural difficulties of gaining access to the workplaces.

Finally, an observation can be made about the use of participant perceptions as a data source. The students in this study varied widely in their ability (willingness?) to report their learning. It is possible that science and technology students around the age of 20 have not developed adequate reflective abilities, that their relative inexperience in the workplace prevented them from placing their learning into context, or that the novelty of the workplace environment in ways of learning and assessment prevented the students gaining a clear view of learning. However ultimately this study is about their perceptions of their learning, so it remains appropriate that they told their story.

10.6 Conclusion

When a sociocultural lens has been focussed upon cooperative education as in this study, then an image has emerged of a learner at the junction of two complementary communities of practice. This learner, a co-op student, can be seen to be an individual who participates in many different communities (the university, the workplace, the home, the flat, the sports team or church group), and within each community the student constructs an identity that contributes to their own sociocultural history. That history is a result of the sum of the student's experiences and enculturation into the ways of thinking and behaving in each community.

Each student then carries that history into the co-op placement, creating a link between their history and that of the workplace community. Through their participation in this new placement community, they come to socially share in the cognitive and physical processes inherent within it. They gain legitimate access to the tools and artefacts that define that community, and learn to become a

community member. In doing so, they are transformed in both an individual way (based on their sociocultural history) and a sociocultural way. This process leads to a view of the community of practice that is individualised, but also interconnected through its members.

In this manner, a student's learning through cooperative education in science and technology can be theorised. Prior to entering the work placement, this student has been enculturated into thinking about science and technology through two years of university study (in this case), through legitimate access to the social sharing of knowledge through attending lectures and laboratory classes, and reading textbooks and journals. This enculturation has provided ways of thinking about certain phenomena, and some methods of analysing and researching those phenomena that have emphasised the process of doing rather than the outcomes. The student, at this pre-placement stage, has constructed an identity as a science and technology student, who understands their development as a member of the university community through the process of summative assessment, and their success in the community is measured mainly by attainment of qualifications.

This student carries their particular university community history, as well as their history of participation in other communities, into the co-op placement. Within the placement community of practice, the student encounters new knowledge, new ways of thinking and behaving that are constituted in the sociocultural history of that community. The student learns as they come to share, through legitimate participation in socially mediated interactions, in the thinking and behaving of the community, through its members, their tools and artefacts. This student fits these new experiences into their unique sociocultural history, gradually developing their own meaning about the practice of science and technology. The development of the student as a member of the workplace community of practice is viewed as increasing participation within the community, and their success in the community is measured by transition into a practitioner.

Therefore it can be concluded from this study that sociocultural views of learning are useful in conceiving of learning in cooperative education. Utilising these views of learning has enabled a view of the co-op placement as a learning

environment, which is distinct from, but complementary to, the educational institution. Learning is seen to occur through enculturation into each community and its ways of thinking and behaving. The transition from student to practitioner occurs as the student assimilates their construction of a workplace identity into their own sociocultural history.

These conclusions raise some implications about the legitimacy of cooperative education as an educational strategy, and its curriculum and pedagogy. These implications are now discussed

10.7 Implications

The findings of this study raise several implications for consideration by those involved in co-op programmes. These implications are stated as outcomes of this study using the BSc(Tech) programme at the University of Waikato and are written with that programme in mind. The diversity of co-op programmes will necessitate that practitioners consider these implications within the context of their own programme and evaluate which implications may apply to their particular circumstance. Programmes in which the placement coordinator does not play an educative role should consider the implications for the person who does hold the educative role in their programme. These implications are:

1. Cooperative education should be viewed as a valuable and legitimate learning strategy. Co-op programmes allow entry of tertiary students into two distinct communities of practice, in which complementary learning enables the transition from student to practitioner. The placement plays an important role in allowing the student to understand what it means to practice in their subject area. Placements which allow good integration between a student's university study and their workplace experience will tend to maximise learning. However, learning relevant to a student's qualification may still occur in the placement in situations where the placement and the university learning complement each other, rather than integrate. Co-op practitioners can clearly justify the inclusion of a co-op

placement within an educational qualification on the grounds that significant learning is achievable under the right conditions.

2. Sociocultural views of learning suggest curricula and pedagogy for cooperative education that can ensure conditions for learning. This in turn has a number of implications: University-based education should be recognised as enculturation of the student into the university academic community. Teachers and students should be encouraged to recognise its characteristics of learning and assessment. The first implication leads to consideration of learning through a sociocultural perspective at university. This consideration would indicate that more emphasis is placed on teacher and student understanding of learning as a socially mediated activity, in which students draw on ways of thinking that are closely allied to those of their own teachers, their books, and become enculturated into the language of science and technology through discourse (Leach & Scott, 2003). Potential may also exist for re-designing university learning tasks, particularly in the laboratory, that more closely resemble workplace tasks in valuing process and outcomes.

3. Recognition that the learning environments of the university and the workplace are different necessitates a re-consideration of the preparation of co-op students for entry into the work placement. This preparation may involve discussion of the role of work ethics and routines, the development of working relationships, and the importance of the development of personal skills. It should also involve discussion of learning as an activity mediated through social interactions, participation and the use of tools (such as language) and artefacts.

4. Prior to their placements, students should be encouraged to acknowledge and understand their own sociocultural histories, including their experiences in, and their identities within, other communities of practice. Taking this approach would allow the students to understand better their career focus, and their knowledge and skills which they may wish to complement through enculturation into a science and technology

community of practice. It may also permit clear acknowledgement of learning objectives within the placement, and for links to be made between learning in the placement community and their own sociocultural histories.

5. The role of the placement coordinator as an educator becomes clear. The coordinator should seek to help students interpret the experiences within their sociocultural histories and thereby plan to complement and extend their histories through the work placements. Individual learning plans could be constructed to facilitate this. The coordinator must also understand the sociocultural setting of particular workplaces, including the type of work conducted, the workplace staff (in particular the work supervisor) and the norms of behaviour in that community. The coordinator then plays a crucial role in matching the student to an appropriate workplace. Naturally, there are often constraints that prevent a perfect match of student to workplace, and in these, and all, placements, the coordinator should work with the student to assist them to establish links between their sociocultural histories and the new placement community. For example, the coordinator may need to address the concerns of students with little previous work experience prior to their first placement, discuss the different theoretical approaches used in the university and the workplace, or assist the student in interpreting social relationships in the workplace. This broad education role for a placement coordinator has not been clearly argued before in the co-op literature, and adoption of such a stance may necessitate specific training for placement coordinators to undertake the role.

6. Finally, the issue of assessment of placement learning should be considered from a sociocultural perspective. Students should be prepared for an assessment environment in the placement that is different to that which they had experienced in the university. Assessment procedures used to determine student learning on placement should reflect a view of learning as a socially mediated and participatory activity, and recognise increasing participation in the community of practice as a mark of successful achievement.

10.8 Suggestions for further research

This study has contributed to understanding about students learning through work placements. There exists potential for further research in the following areas:

- The examination of student learning in other placement programmes through the lens of sociocultural views of learning. A question arises as to whether the structure of the placement in other contexts, e.g. nursing or teaching, would provide findings similar to this study. How does the nature of the student's participation in the workplace affect the learning process and outcomes? Does the duration and timing of the placement within a qualification affect the learning process and outcomes?

- Research should be conducted into changes in student modes of learning between the classroom and workplace environments. The work placement offers the potential to begin a transformation in what is valued in learning between the institutional-based learning for assessment and qualification, to the workplace-based learning for participation. The adaptation through the work placement to the latter style of learning may indicate the usefulness of the placement in creating an individual more attuned to adult learning throughout their life.

- Assessment of the work placement remains a key issue, upon which this study has only commented lightly. More research into assessment methods which can illuminate student learning from a sociocultural viewpoint may prove to be useful.

- The educative role of the placement coordinator, or other person responsible for monitoring and enhancing student learning on placement. Research is required into the key factors that affect the performance of this person, and development and training that could enhance the role.

- It would be of interest to conduct research with the participants of this study, in order to investigate their perceptions of how their learning through their work placements and their university study contributed to their enculturation into the communities that they have entered since completing their degrees. Of particular interest would be to explore whether after a period of time in the workforce, or in higher study, their views had changed about the value of what and how they learnt in their co-op degrees.

As noted at the beginning of this thesis, the cooperative education community has been calling for more research from its practitioners. This study has contributed to that call, but there remains much more to be done to ensure that the practice of cooperative education continues into a brighter future.

Postscript

At the conclusion of this study, all the students who participated had graduated and moved on to the next stages of their career. These next career moves included:

- Seven students have completed or completing their masters degrees in science and technology. Two of these have gone on to PhD degrees in science.

- Two students who were employed by their placement organisations at the end of their co-op degrees are still with those companies and enjoying the work.

- Three students are working in science and technology, in positions they gained at least in part due to their co-op placements.

- One student has subsequently completed teacher training and is now teaching in a primary school.

- Two other students are taking time out to travel and consider their next career option.

- Ten students were uncontactable.

Appendices

Appendix A – Participant Backgrounds

Listed below are the 22 participants of the longitudinal study and some brief background on them. Pseudonyms have been used in all cases. The code used for quotes in the thesis from each participant is also shown.

Kathy was an earth science major. She came to University to do biology but switched to environmental science and had a particular interest in floods. She is a New Zealand European and was 20 years old when she entered the programme, entering university straight from school. Code Ba/x/x.

Grant was a materials and process engineering major. At the beginning of the programme he was unsure of where he wanted to head. He is a South African who did all his schooling in South Africa before emigrating to New Zealand, and was 20 years old when he entered the programme, entering university straight from school. Code Be/x/x.

Kara was an earth science major. She has a particular interest in environmental issues and completed the resources and environmental planning programme. She is a New Zealand Maori/European, and was 20 years old when she entered the programme, after completing a year of work in the retail sector since leaving school. Code De/x/x.

Joanne was a computer science major. Her main interest was in programming and information systems and databases. She is a New Zealand European and was 20 years old when she entered the programme, entering university straight from school. Code Ev/x/x.

Karl was a materials and process engineering major. He left school and worked for a number of years before deciding to come to university. He had gained an New Zealand Certificate of Engineering but realised he had got as far as he could go with that. He is a New Zealand European, and was 22 years old when he entered the programme. Code Fr/x/x.

Nigel was a chemistry major and is originally from England, arriving in New Zealand in 1995. He is English, and was 19 years old when he entered the programme, entering university straight from school. Code Gr/x/x.

Christine was an earth science major. She had left school early and worked for a number of years before deciding to come to university. She is a New Zealand European, and was 23 years old when she entered the programme. Code Ha/x/x.

Duncan was an earth science major with an interest in environmental science and soils. He is a New Zealand European, and was 19 years old when he entered the programme, entering university straight from school. Code Ho/x/x.

Jill was an earth science major. She had a particular interest in the dairy industry and environmental issues. She is a New Zealand European, and was 20 years old when she entered the programme, entering university straight from school. Code Le/x/x.

Mike was an earth science major and was particularly interested in soils. He is a New Zealand European, and was 19 years old when he entered the programme, entering university straight from school. Code Mc/x/x.

Joe was a chemistry major. He is a New Zealand European and was 19 years old when he entered the programme, entering university straight from school. Code Mi/x/x.

Sally was a forestry major. She is a New Zealand European, and was 20 years old when she entered the programme, entering university straight from school. Code Mo/x/x.

Donna was an earth science major. She had a particular interest in water science. She is a South African European who emigrated to New Zealand and completed her final two years of schooling in New Zealand. She was 19 years old when she entered the programme, entering university straight from school. Code Ni/x/x.

Rick was a physics major, specialising in electronics. He has an interest in working in the aviation industry. He is a South African European who completed his schooling in New Zealand. He was 19 years old when he entered the programme, entering university straight from school. Code Pa/x/x.

Jeff was a forestry major. He is a New Zealand European and was 19 years old when he entered the programme, entering university straight from school. Code Rh/x/x.

Martin was a technology major, specialising in material science. He is a New Zealand European and was 19 years old when he entered the programme, entering university straight from school. Code Ri/x/x.

Victor was an electronics major, with an interest in computer programming. He is a New Zealand European and was 19 years old when he entered the programme, entering university straight from school. Code Ro/x/x.

James was an electronics major. He had previously worked for four years in a science research institute. He is a New Zealand Maori and was 24 years old when he entered the programme. Code Sk/x/x.

Vanessa was an earth science major, with biology as a supporting subject. She is a New Zealand European and was 19 years old when she entered the programme, entering university straight from school. Code Sto/x/x.

Lucy was a technology major, specialising in biotechnology. She is a New Zealand European and was 19 years old when she entered the programme, entering university straight from school. Code Str/x/x.

Craig was a computer science major. He is a New Zealand European and was 19 years old when he entered the programme, entering university straight from school. Code Su/x/x.

Nancy was a chemistry major. She is New Zealand Chinese and was 19 years old when she entered the programme, entering university straight from school. Code Wo/x/x.

Appendix B - Graduate Survey

When answering the following questions, please consider only your last work placement in your BSc (Technology) programme.

A. General Questions

A1. In what year did you complete your last placement for your Bachelor degree?

A2. What was your subject major/specified programme?

A3. What was the duration of that placement? (Tick one)

Up to 4 months ☐ 5-9 months ☐ more than 9 months ☐

A4. What was the primary nature of the **business of the organisation** in which you carried out your last work placement? (Tick only one box)

Research..... ☐

The provision of commercial products or services ..... ☐

Council activities..... ☐

The provision of public services..... ☐

Other (specify) .....

.....

A5. How many staff worked for the organisation that you worked for?

(Tick one) 1-10 ☐ 11-50 ☐ 51-500 ☐ >500 ☐

A6. How many people were you working and interacting with on a daily basis?

(Tick one) 1-2 ☐ 3-5 ☐ 6-10 ☐ >10 ☐

A7. Briefly describe the work that you did in your last placement.

.....

.....

.....

.....

A8. Have you undertaken a Masterate/Doctorate in science/technology after completing your Bachelors degree?

YES / NO (circle one)

A9. What activity are you currently engaged in? (Tick any that apply)

Currently studying towards a Masters/Doctorate in science/technology	☐
Working in science/technology	☐
Working, but not in science/technology	☐
Not Employed	☐

B. Learning in the Workplace

B1. What are the things that you learnt in your last placement?

B2. Who contributed to your learning of these things?

B3. How did you learn these things?

B4. In what ways did you feel that you were able to apply what you had learnt in university?

B5. How has what you learnt on your last work placement helped you in the next stage of your science/technology career (e.g. Masterate, Job in science/technology)?

C.Working Knowledges

I have identified five knowledge areas that can be important in the workplace. I am interested to know what contributions these knowledges made to your learning in your last placement. Please tick the response that most closely fits according to the scale below.

1	2	3	4	5
Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

C1.Theoretical knowledge e.g. scientific and technological information, background theory etc

	Strongly Agree 1	2	3	4	Strongly Disagree 5
a. I learnt theoretical knowledge in my placement	☐	☐	☐	☐	☐
b. Theoretical knowledge learnt in the placement helped me to do my work	☐	☐	☐	☐	☐
c. Theoretical knowledge learnt in the placement integrated well with what I had learnt at varsity	☐	☐	☐	☐	☐
d. Theoretical knowledge learnt in the placement helped me to feel more a part of the company	☐	☐	☐	☐	☐

e. I learnt theoretical knowledge from: (Tick any that apply)

attending group meetings	☐	reading company material	☐
talking to my work supervisor	☐	talking to my co-workers	☐
reading relevant science/technology published papers	☐	talking to my university supervisor	☐

other (specify).....

f. *Please go back and make a double tick beside the source of most learning in e.*

C2. Workplace language e.g. technical jargon, abbreviations, nicknames etc

	Strongly Agree 1	2	3	4	Strongly Disagree 5
a. My workplace had some elements of language that were particular to it	☐	☐	☐	☐	☐
b. Learning the workplace language helped me do my job	☐	☐	☐	☐	☐
c. Knowing the workplace language helped me feel more a part of the company	☐	☐	☐	☐	☐

d. I learnt workplace language from: (Tick any that apply)

reading company material ☐ talking to my work supervisor ☐

attending group meetings ☐

reading relevant science/technology published papers ☐ talking to my co-workers ☐

other (specify).....

e. *Please go back and make a double tick beside the source of most learning in d.*

C3. Workplace "rules" e.g. the way things are done around here, customs of the organisation etc.

	Strongly Agree 1	2	3	4	Strongly Disagree 5
a. I learnt "rules" about working in science/technology in my placement	☐	☐	☐	☐	☐
b. These "rules" helped me to do my job	☐	☐	☐	☐	☐
c. Knowing the "rules" helped me to feel more a part of the company	☐	☐	☐	☐	☐

d. I learnt these"rules" from: (Tick any that apply)

attending group meetings ☐ talking to my work supervisor ☐

talking to my co-workers ☐ reading company material ☐

observing interactions at work ☐

other (specify).....

e. *Please go back and make a double tick beside the source of most learning in d.*

C4. Workplace skills and techniques e.g. technical skills, communication skills, how to do tasks properly etc.

	Strongly Agree 1	2	3	4	Strongly Disagree 5
a. I learnt skills and techniques in my placement	☐	☐	☐	☐	☐
b. These skills and techniques helped me to do my job	☐	☐	☐	☐	☐
c. Knowing these skills and techniques helped me to think that I was contributing to the company's business	☐	☐	☐	☐	☐

d. I learnt workplace skills and techniques from: (Tick any that apply)

reading company material	☐	my work supervisor	☐
my co-workers	☐	reading relevant science/technology published papers	☐

other (specify).....

e. *Please go back and make a double tick beside the source of most learning in d.*

C5. Workplace relationships e.g. lines of authority, responsibility, who likes/dislikes who etc.

	Strongly Agree 1	2	Neither 3	4	Strongly Disagree 5
a. I learnt about the influence of workplace relationships in my placement	☐	☐	☐	☐	☐
b. Understanding these relationships helped me do my job	☐	☐	☐	☐	☐
c. Knowing these relationships helped me feel to feel more a part of the company	☐	☐	☐	☐	☐

d. I learnt about these relationships from: (Tick any that apply)

attending group meetings	☐	talking to my work supervisor	☐
talking to my co-workers	☐	observing interactions at work	☐

other (specify).....

e.*Please go back and make a double tick beside the source of most learning in d.*

D. Who helped you learn?

In this section I am interested in who helped you to learn in your last placement.

D1. Work Supervisor/Day to day Boss

	Very significantly 1	2	3	4	*Not at All* 5
a. My work supervisor/boss contributed to my learning			*(circle one)*		

b. How did they help you to learn?

c. What did they help you to learn about?

D2. Co-worker(s)

	Very significantly				*Not at All*
a. My co-worker(s) contributed to my learning	*1*	*2*	*3*	*4*	*5*

(circle one)

b. How did they help you to learn?

c. What did they help you to learn about?

D3. University supervisor

	Very significantly				*Not at All*
a. My university supervisor contributed to my learning	*1*	*2*	*3*	*4*	*5*

(circle one)

b. How did they help you to learn?

c. What did they help you to learn about?

D4. Placement co-ordinator

	Very significantly				*Not at All*
a. My placement co-ordinator contributed to my learning	*1*	*2*	*3*	*4*	*5*

(circle one)

b. How did they help you to learn?

c. What did they help you to learn about?

D5. Who contributed most to your learning during your work placements?

D6. Why do you feel that you learnt more from this person?

E. Induction to work

Organisations sometimes carry out induction courses for new employees. These courses can last for anything from 10 minutes to one or two days, and often cover such things as introductions to existing staff, company philosophy, company rules, health and safety issues etc.

E1. In your last placement, were you given an induction into the workplace and the company you were working for?

Yes / No (Circle one)

If yes, please answer question E2. If no, please go to E3.

E2. I felt that the induction was very effective (circle the most appropriate statement)

1	2	3	4	5
Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

E3. What else would you like to have known about that you weren't told at the very beginning of that placement?

F. Assessment of Workplace learning

F1. Do you think the assessment process for your placement gave you an opportunity to demonstrate your learning in the work placement?

F2. Do you think that the grade you received for the placement was a fair reflection of the learning that you achieved in the work place?

F3. In what ways is it important that you were assessed on your work placement?

Thank you very much

for taking the time to fill in this questionnaire.

Appendix C

Interview protocols

Appendix C.1

Interview 1 Questions

Code **Date of interview**

1. Background/Course of study

General - I want to know some background information about where the student has come from, a little about their personal background and what they are studying at University.

Interview Text - not all questions were asked

Firstly I'd like to find out a little about you and what you are doing at University!

Where are you from?

May I ask how old you are?

How would you describe your ethnic background?

What are your parents occupations?

Which secondary school did you go to?

Why did you decide to come to university?

So you first came to the university to study in 1997?

Tell me about what you are studying this year at university?

Which topics are most interesting?

Why are you particularly interested in these topics?

Research Focus

Who is this student? What is their background experience and family situation? What is their motivation? What area of science and technology are they studying and interested in?

2. Interest in, and understanding of science/technology

General - I want to know how the student became interested in science and technology and what their general understanding of these disciplines is and what it means to practise in them.

How did you first get interested in science and technology?

What sort of contribution do you think science and technology can make in today's world?

What do you think science is all about?

How do you describe what a scientist does?

What do you think technology is all about?

How do describe what a technologist does?

Do you see yourself as more interested in science, or technology, or is there no difference for you?

Research Focus

Why is this student interested in science and technology? What is their motivation?

What do they understand about science and technology, and what it means to do science and technology?

3. University Learning

General - I want to know how students perceive their own learning at university and in general, and the relevance of some aspects of their university education.

I'd like spend to some time reflecting on some general questions about your learning at university. Please be as honest as you can, this information will be completely confidential.

What do you think you learn from going to lectures?

Is it an effective learning environment for you?

Do you do extra reading around the lecture material? Does it help?

What do you think you learn in practical sessions?

How do you learn these things?

Are labs an effective learning environment for you?

How else do you do your learning at university? What works for you?

How do you feel about the relative importance of learning theory and practice in your studies?

What do you think about the relevance to the real world of things that you learn at university?

How do you feel about being assessed on what is taught?

Which methods of assessment do you think allow you to demonstrate your learning the most?

Research Focus

What and how is the student learning at university, what importance do they attach to that learning, and the learning environment, how that learning fits into their overall education and achievement.

4. Expectations of the workplace - work to be done, roles of people around you (work supervisor, co-workers, academic supervisor, placement coordinator)

General - I want to find out about previous work experience, particularly in the sci/tech field, and then student's expectations about what they will be doing, what it will be like to work in sci/tech organisations, and what and how they think they might learn.

I'd like to focus now on your work experience to date.

Tell me about your work experience to this point?

How did you feel about those jobs?

What was it like working in .....(those organisations)?

Now let's focus on what it might be like at work in your placement this summer.

You have a got a placement lined up at ..... . What do you think you will be doing in that job?

What do you think it will be like working at .....?

What do you think the people will be like?

How would you describe the culture that you think might exist in the company?

What do you think you might learn on your placement?

What do you hope to learn?

How do you think you might learn while on placement?

Who do you think might be important to you during your placement in helping you learn?

How might they help you learn?

Research Focus

These are the key questions regarding perceptions and expectations of learning- what are the student's perceptions of what the placement will be like, and what is the student expecting out of the experience.

5. Career plans

General - I want to know what students have in the back of their minds regarding what they are doing the programme for.

To conclude I'd like to find out what your expectations are for the future with this degree.

What do you hope to get out of doing the BSc(Tech) degree?

At this stage of your studies, what options might you consider to follow after you have finished your BSc(Tech) degree?

Research focus

Where is the student headed with their science and technology?

Appendix C.2

Interview 2 - Questions

Code **Date of interview**

General questions

1. Background

What is the official name of this organisation?

What is your official position designation for this placement here?

Who is your work supervisor? How often do you see this person?

Who else do you work with? (What are their position(s)?)

How many months/weeks will you be working here roughly?

How many hours do you work a week?

What is your pay rate per hour?

2. The Workplace

Feelings for the Company and the Work

What has it been like working here?

What have you been doing?

How would you describe your role in this company?

How have you felt about this role – the work you have been doing? (Do you think your work is valuable?)

What value do you feel the work the company does has to society?

Have you done what you thought you were going to do? (Has any aspect of the work surprised you?)

Has the placement lived up to your expectations?

Have you felt motivated to do a good job here?

(If so) What motivates you to do a good job here?

How do you feel about how much you have been paid for what you do?

(In comparison to others here, or elsewhere?)

Has your pay rate influenced your thinking about a career in science and technology?

Induction and Belonging

What was like working here in the first few weeks?

Did you receive an induction or orientation?

What did it involve? What did it cover?

Is there anything else you would liked to have known before you started working here?

How do you feel now about working here as compared to when you started?

Do you feel a part of this organisation? Why/why not?

Culture and Purpose of the Organisation
People talk about an organisation having a particular culture or atmosphere, based around things like how hard people work, what they do at work, what they talk about.

Is there a particular culture or atmosphere here? How have you found this out?

Can you describe the purpose of this organisation? (What is it here to do?)

What have you learnt about the type of work/industry(*use specifics for each student*) this organisation is involved in from working here?

Has the placement helped you understand what it is like to be at work? How?

People at Work

What have the people been like? Have you got on with some/all of them? Why/why not?

(How have people at work reacted to you as a university student?)

Do your workmates think it's a good idea you are doing this placement as part of your degree? Why? (How do you know?)

Do you know how your workmates feel about working here?

Concerns and Mistakes

Have you any concerns about what you have been doing, or how the placement has gone?

Have you made any mistakes at work?

What happened?

Were there any repercussions?

What did you learn from it?

What do you do at work when you don't know or understand something?

Teamworking
Have you been working mainly individually or as a team member? (Mostly?) How do you feel about these ways of working?

3. Learning

Log Book
Have you been using your learning logbook? Is there anything there we could talk about?

Challenge and Opportunities
What have been the challenges for you? (Mental, physical, time management).

Do you feel that you have had enough opportunities to learn here?

Conjunction with University Learning
What value has your university learning been to you in this work place?

Has it been relevant? (Have you been able to apply it?) (Has it been valuable to the company do you think?)

Are you learning in a different way to how you learnt at university? How?

Feedback and Assessment
How much feedback have you been getting? How do you feel about the feedback you get? What forms does it take?

Do you feel they value the work you are doing here?

Do you feel you have had opportunities to contribute, comment, question?

How do you feel you should be assessed for your placement to be able to show your learning?

Working Knowledges
What theoretical knowledge have you learnt here?

How have you learnt this?

What skills have you learnt here?

How have you learnt them?

Are there particular ways of doing things around here? (e.g. work hours, breaks, techniques, asking for something etc). Are there any peculiar customs?

How have you learnt these things?

Is there any particular language (technical jargon, in-house lingo, nicknames) used in this workplace?

How have you learnt it?

What have you learnt about getting on and working with people here? (you to them and them to them)

How have you learnt this?

How have you got with your supervisor workwise? Socially?

How have you got with your co-workers workwise? Socially?

What role has your university supervisor played in your placement so far?
What role has your placement co-ordinator played in your placement so far?

Has anyone else been helpful to your learning here? (How have they helped?)

Wrap-up
Is there anything else that you know now that you didn't before you started here?

How have you come to know it?

4. Science and Technology

Do you consider what you have been doing here as science or technology, or both? Why/why not?

What have you learnt about being a scientist/technologist in this placement?

What have you learnt about the process of doing science/technology in this placement?

5. Career Direction

What value do you place on your experience here? (Your learning).

Has working here influenced your thinking about your career and short term future?

Has working here helped you with your decision about what courses to take, and what career direction to follow?

How are you feeling now about going back to university?

Do you think you will be able to use at university things you have learnt here? How? What about longer-term?

Appendix C.3

Interview 3 Questions

Code **Date of Interview**

This is a general set of questions that was personalized to each participant based on previous interviews.

Personal Development

How do you feel about your first placement now looking back on it?

What were the good things?

Were there any bad things?

What do you think you got out of your first placement? What effect has it had on you?

Do you think you have developed as a person with the experience? How? Has anything changed for you?

Understanding the Workplace

What's your perception of <company> as a place to work?

Do you feel that you got a good understanding of the company you worked for? How did you get this understanding?

Did you get a feel for what the people around you did? How did you get this understanding?

What do you think are the key attributes that someone who wanted to work there should have?

Learning in the Workplace

What do you think you learnt in your placement?

What was the best way that you learnt stuff? Other ways?

How important were the people to you in the workplace? In terms of your learning?

Who was important? Were they more important than your own efforts?

Science and Technology

Did your placement help you to understand what it is like to work in science/ in technology? What did you learn?

Where was the science in your placement? Where was the technology?

Do you think that your conception of what science/technology is has changed since you have done your placement? And about how it is practised?

(Think back to your ideas before your placement).

What does it mean to you now to do science/technology?

Has the placement changed your feelings about a career in s and t?

Assessment and the Report

Did writing the report help you to understand the work you did, the organisation you worked for?

How did it help? Who helped?

Was the assessment process fair for you?

Integration into University

Have you been able to use anything (skills/knowledge) learnt in the placement back here at university?

Do you feel your approach to your studies has changed since your work placement? (motivation, interest, style)

Have you found your courses more interesting this year, in the light of your experience? Have you felt more motivated?

How do you feel now being back at university?

Next Placement

How are you feeling about taking on a second placement this summer?

Has your thinking changed at all about where you are heading?

Do you have a placement arranged for this summer?
What are your expectations of that?

What sort of placement would be of value to you?

Appendix C.4

Interview 4 - Questions

Code **Date of Interview**

This is a general set of questions that was personalized to each participant based on previous interviews.

1. General questions

What is the official name of this organisation?

What is your official position designation for this placement here?

Who is your work supervisor? What are their position(s)?How often see?

Who else work with?

How many months/weeks will you be working here?

How many hours do you work a week?

What is your pay rate per hour?

How do you feel about that? (Put off sci & tech?)

2. The Workplace

Feelings for the Company and the Work
What has it been like working here?

Tell me in general terms about what you have been doing since you started working here?

Is this a good company to work for?

Have you been motivated to do a good job here?

Have you done what you thought you were going to do? Has any aspect of the work surprised you? Has the placement lived up to your expectations?

Differences to 1st placement? Better idea of what to expect?

Induction and Belonging
What was it like in the first days/weeks? In comparison to 1st placement?

How was the settling in process for you? Did you receive an induction? What was it like?

Is there anything else you would liked to have known when you started working here?

How do you feel now about working here as compared to when you started?

Do you feel a part of this organisation? Why/why not?

Differences to 1st placement?

Culture and Purpose of the Organisation

What's this workplace like? How does it compare to previous?

Do you recognise a similar culture? What characterises it?

Is there anything different/unusual at all about this workplace so far for you?

What is the purpose of this organisation?

What have you learnt about this industry from working here?

Has this placement helped you understand the world of work? How?

People at Work
How important have the people at work been to you? Why? Who?

Concerns and Mistakes
Have you any concerns about what you have been doing, or how the placement has gone?

Have you made any mistakes at work?

3. Learning

What do you think you have learnt in this placement? How have you learnt those things?

Do you feel that you have had enough opportunities to learn here?

What do you think influences the amount of learning that you can actually achieve in a work place?

When you think of the learning process that goes on for you in a work place do you think it's continual or is it more incremental like step by step?

Have you been challenged in your work? Why/why not?

Differences to 1st placement?

Working Knowledges
What theoretical knowledge have you learnt here? How have you learnt this?

What skills have you learnt here? How have you learnt them?

Are there particular ways of doing things around here that you hadn't come across before? How have you learnt these things?

Is there any particular or unique language used in this workplace? How have you learnt it?

What have you learnt about workplace relationships? How have you learnt this?

What role has your university supervisor played in your placement so far?

What role has your placement co-ordinator played in your placement so far?

Has anyone else been helpful to your learning here? How have they helped?

Conjunction with University Learning
What value has your university learning been to you in this work place?

Has it been relevant? Have you been able to apply it? Has it been valuable to the company do you think?

Do you feel you were well prepared for this placement?

How do you compare the value of doing the work placements with your courses at university?

Do you think of your placements as an integral part of your degree, or do you see them as something separate?

How do you feel about your degree overall?

Feedback and Assessment
Have you been getting much feedback here? How do you feel about the feedback you get here? What forms does it take?

Having already done one placement and been assessed on it, how do you feel you should be assessed for your placement to be able to show your learning?

4. Science and Technology

Do you consider what you have been doing here as science or technology, or both? Why/why not?

What is the relationship between science and technology do you think?

What have you learnt about being a scientist/technologist here?

What have you learnt about the process of doing science/technology in this placement?

5. Career Direction

What value do you place on your experience here?

Has working here influenced your thinking about your career and future?

What's next for you?

Appendix D

These tables record the raw data that provided the figures for the graduate survey report in Chapter 5.

1. Graduate perceptions of what they learnt in the work placement (number of respondents)

Work specific skills	Work generic skills	Personal development	Understanding of organisation, industry and career
86	58	42	40

2. The learning of technical skills correlated to the organisation's business focus (means of responses on a 5 point Likert scale where 1=strongly agree, 5=strongly disagree about learning technical skills)

Local govt	Commercial company	Research institute	Overall
1.62	1.32	1.31	1.35

3. Graduates reporting learning theory in their placement (% of respondents)

Local government	Commercial company	Research institute
76	86	96

4. Graduate perceptions of how they learnt in the work placement (number of respondents)

Practicing doing tasks	Being shown what to do	Through discussion	Being given instructions	Through asking questions
49	32	24	19	20

5. Graduates reporting how they learnt in their placements according to the length of their placement (% of respondents)

	Practicing doing tasks	Being shown what to do	Through discussion	Being given instructions	Through asking questions	Read published material
< 4 months	68	19	23	13	13	23
5-9 months	58	33	27	24	29	23
> 9 months	57	28	14	7	21	7

6. Graduates reporting how they learnt in their placements according to the nature of the employing organisation's business (% of respondents)

	Practicing doing tasks	Being shown what to do	Through discussion	Being given instructions	Through asking questions	Read published material
Local govt	77	15	0	8	31	23
Commercial company	60	37	23	23	31	14
Research institute	57	34	34	25	14	36

7. Graduates reporting how they learnt in their placements according to the size of the employing organisation (% of respondents). Note sample size for small businesses was only 6.

	Practicing doing tasks	Being shown what to do	Through discussion	Being given instructions	Through asking questions	Read published material
Small	100	50	33	33	67	16
Small/medium	42	16	16	8	16	25
Medium/large	60	30	21	19	19	26
Large	62	42	29	21	21	25

8. Graduates reporting whom they learnt from in their placements (number of respondents).

Work supervisor	Workmates	Myself	University supervisor	Parent	General public
82	76	5	3	1	2

9. Graduates reporting how they learnt from their work supervisors and their workmates in their placements (number of respondents).

	Asked questions	Discussions	Gave feedback and support	Through observation
Work supervisors	10	60	12	11
Workmates	9	53	14	22

10. The contribution of learning by a work supervisor and workmates correlated to the focus of the employing organisation's business (means of responses on a 5 point Likert scale where 1=strongly agree, 5=strongly disagree about their contribution).

	Work supervisor	Workmates
Local government	2.09	1.70
Commercial/manufact.	1.72	1.73
Research	1.76	1.80
Overall	1.74	1.75

11. The contribution of learning by a work supervisor and workmates correlated to the size of the employing organisation (means of responses on a 5 point Likert scale where 1=strongly agree, 5=strongly disagree about their contribution). Note sample size for small businesses was only 6.

	Work supervisor	Workmates
Small	1.49	2.26
Small/medium	1.51	1.75
Medium/large	1.68	1.74
Large	2.04	1.65
Overall	1.67	1.86

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